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PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

SEPTEMBER 1953

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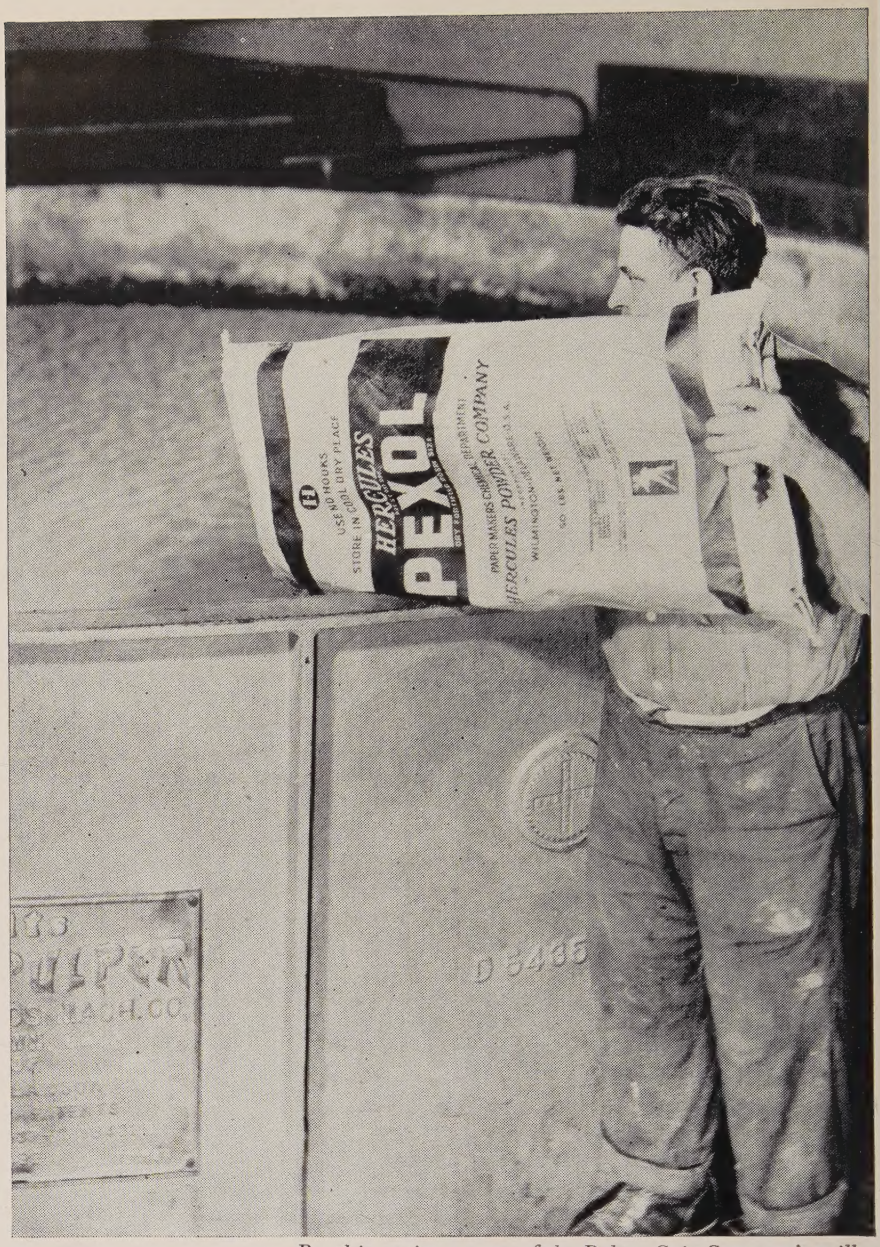

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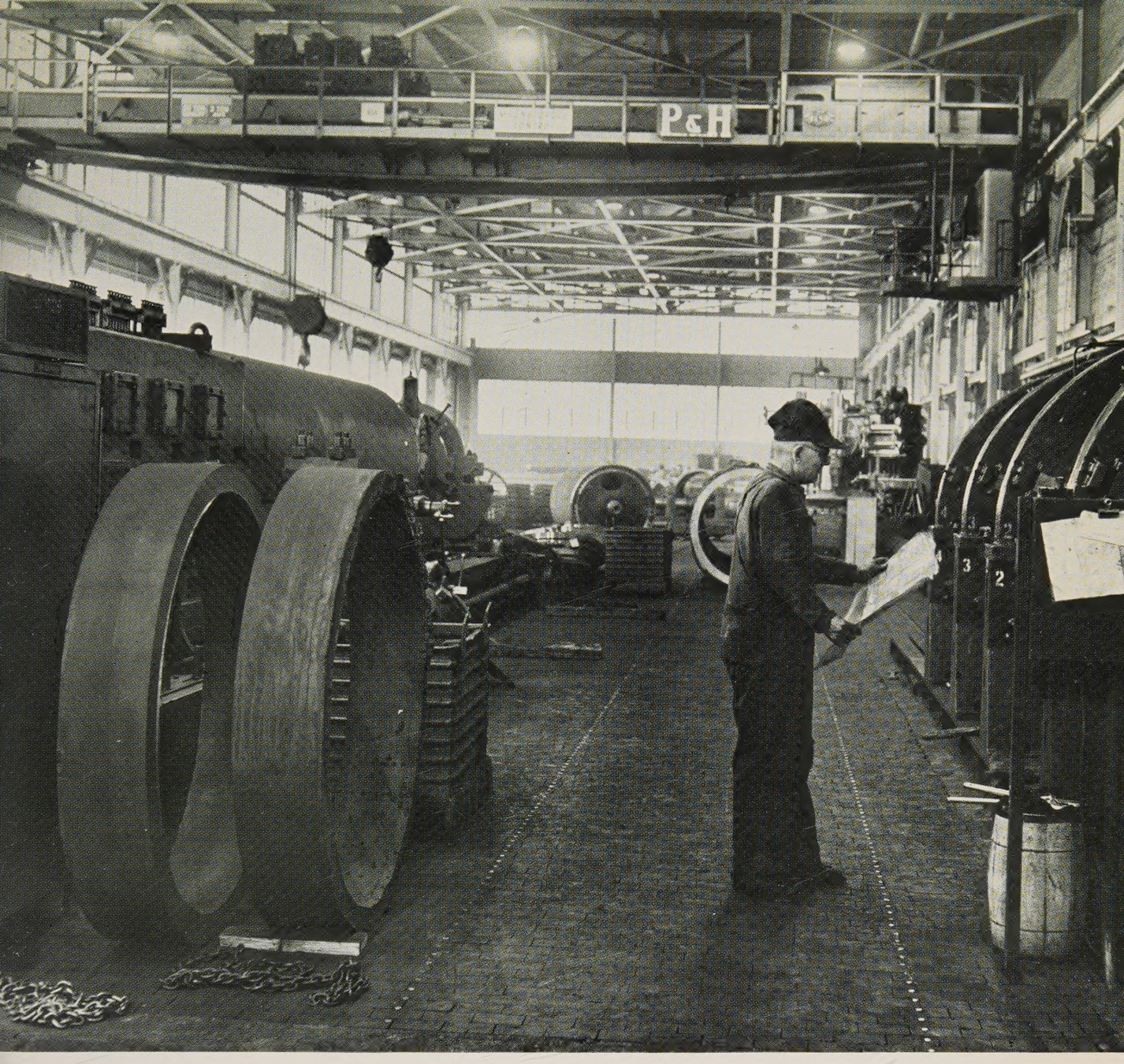

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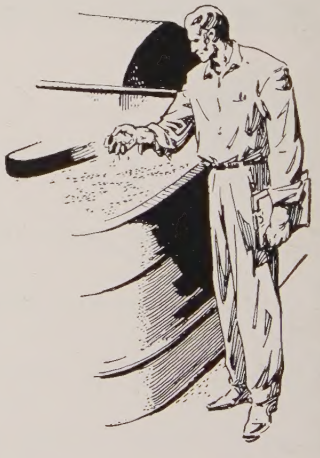

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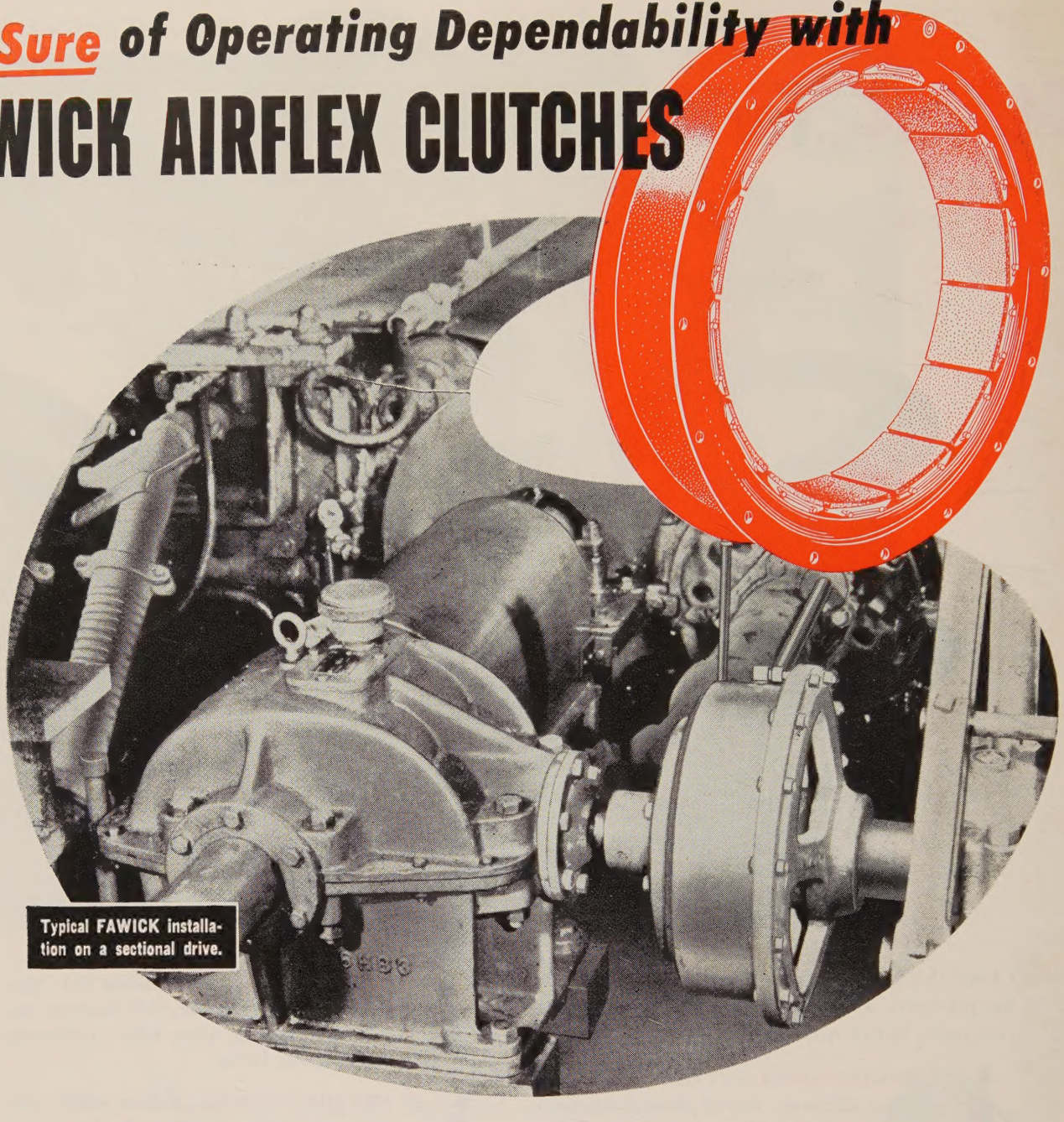

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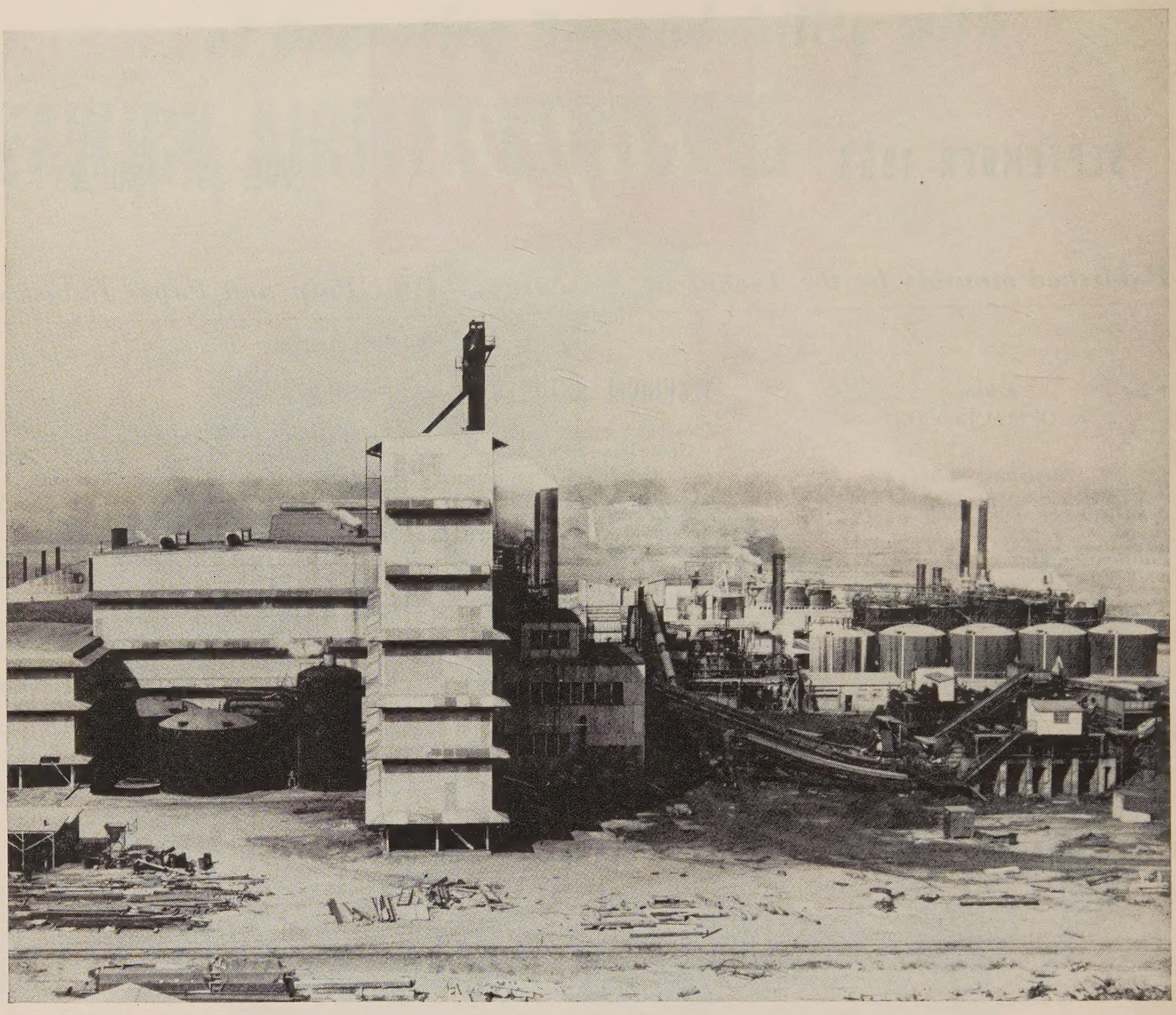

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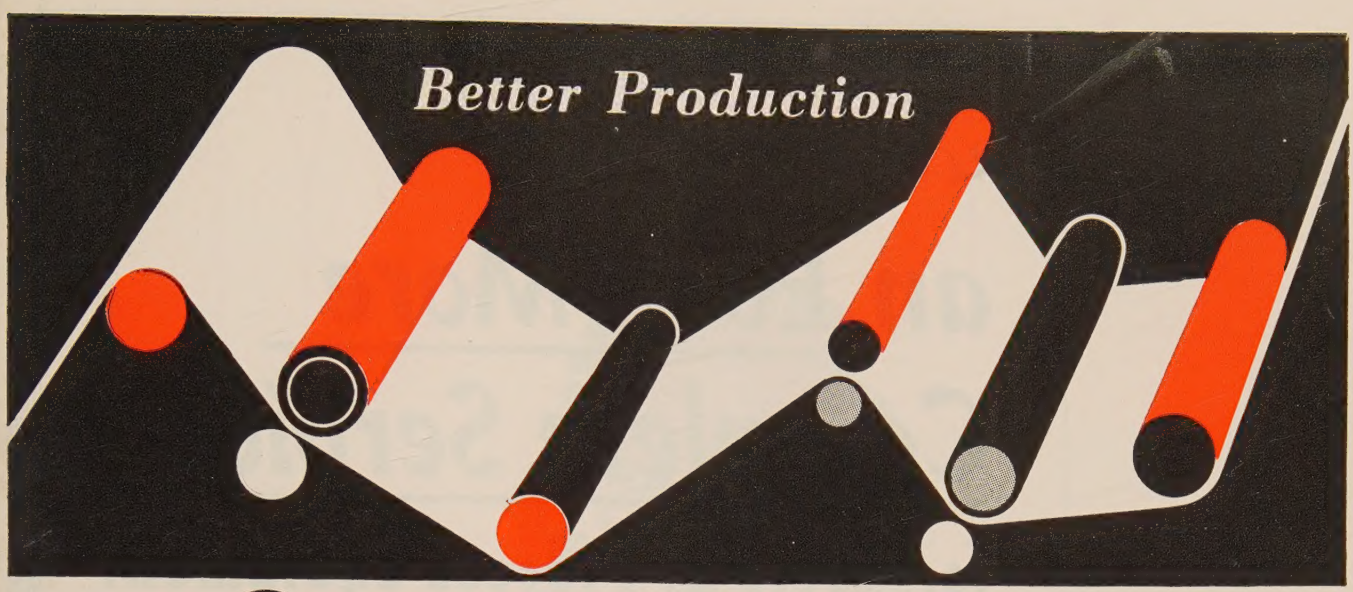

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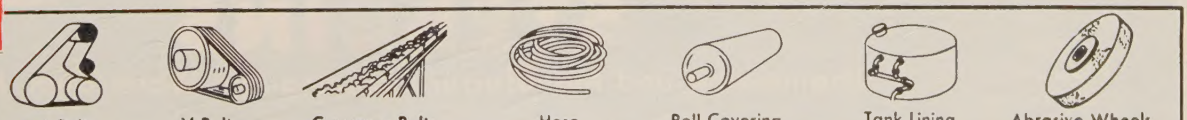

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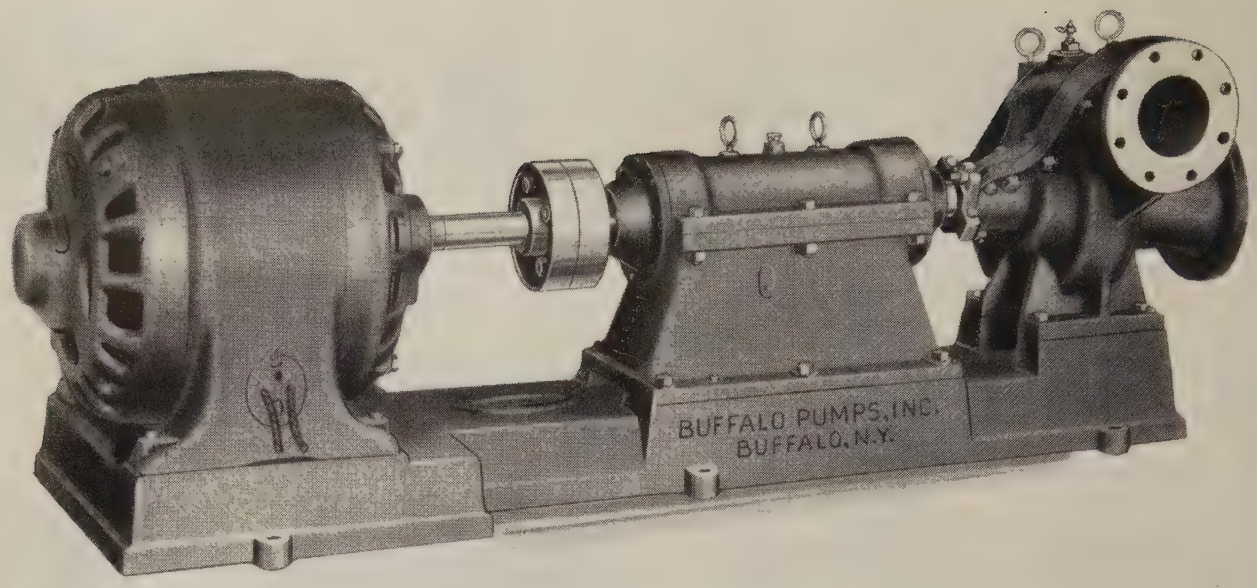

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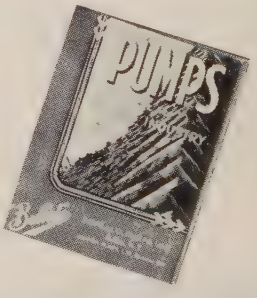

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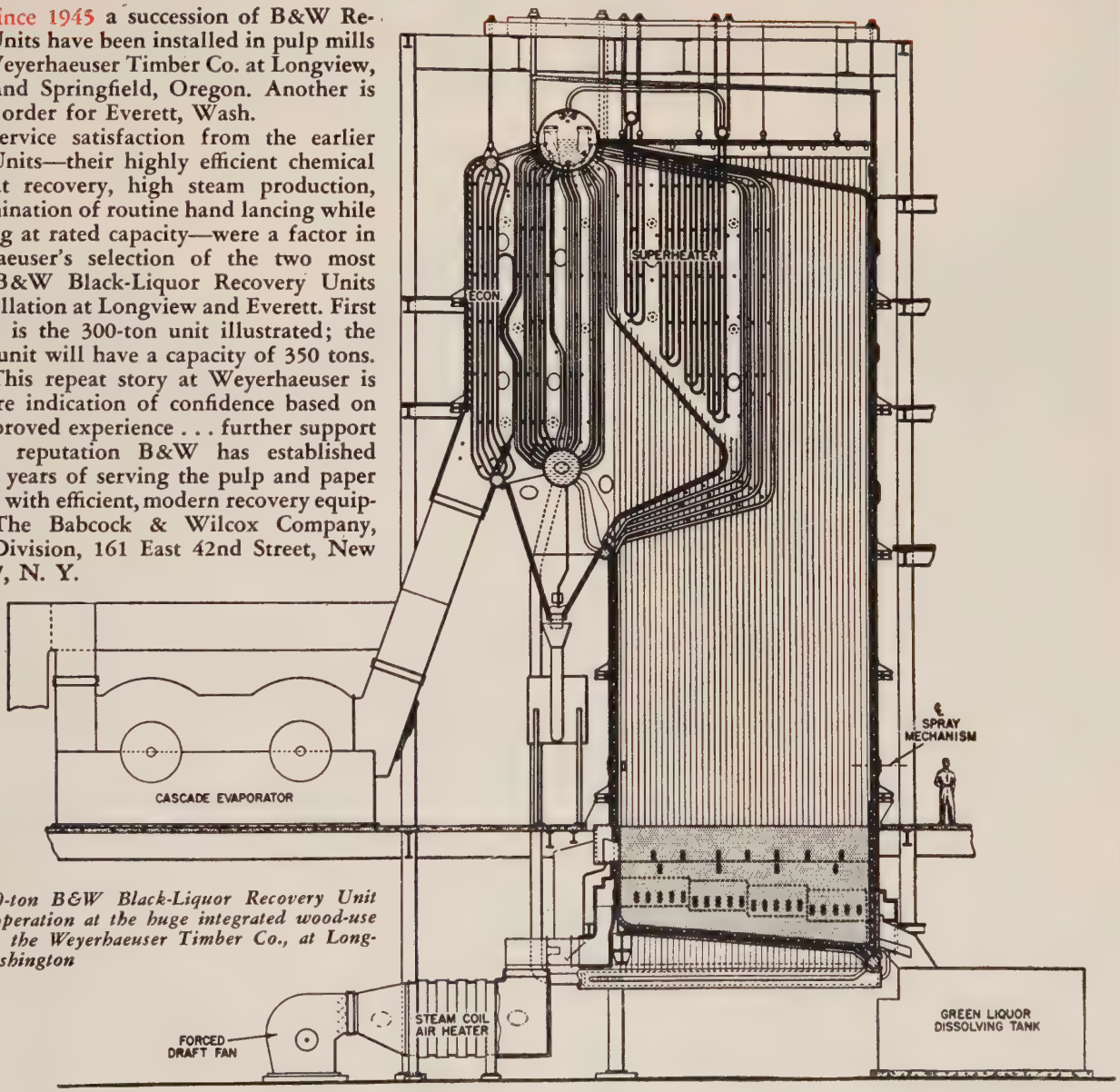


New 300-ton B&W Black-Liquor Recovery Unit now in operation at the huge integrated wood-use center of the Weyerhaeuser Timber Co., at Longview, Washington

B&W BABCOCK & WILCOX

P-774

Progress in the Utilization of Spent Sulphite Liquor

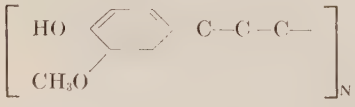
W. M. HEARON

THE profitable utilization of spent sulphite liquor presents one of the largest and most challenging problems faced by any industry today. What is now in general a liability may in the foreseeable future become an asset which could change the economics of sulphite pulp and paper manufacture. Progress in this direction is indeed being made, although much effort will still be required to put all of this waste material on a paying basis.

What is spent sulphite liquor? Pulping of wood by the sulphite process is carried out by digesting wood chips at about 130°C. for several hours with a solution of sulphurous acid and a bisulphite salt. Generally the cation is calcium although one United States mill uses magnesium and several employ ammonia. During the digestion the lignin is dissolved in the form of lignin sulphonic acid and concurrently some carbohydrate material is hydrolyzed and dissolved. The resulting solution of these chemicals which are removed from the pulp at the completion of the digestion is termed spent sulphite liquor.

In addition to the two main reactions noted above, the sulphite pulping operation has many secondary reactions occurring on a limited scale. As a result, many other compounds besides sugars and lignin sulphonic acid occur in small amounts in the liquor. A fairly complete list of the spent sulphite liquor constituents is given in Table I. A little chemical ingenuity can account for most of the trace compounds by reaction of lignin or sugars with acid or by oxidation and reduction both of which can occur with bisulphite.

By far the main constituent of spent sulphite liquor is the lignin sulphonic acid. Despite the extensive research on lignin, its structure remains unknown. Certain facts, however, are fairly well established for lignin sulphonic acid. It is almost assuredly a repeating polymer of guaiacyl propane units not necessarily each



having the same structure as the next. The molecular weight of this acid has been variously reported over a wide range but for conceptual purposes a figure of 5000 for the average gives a fairly accurate picture. In any case, the so-called lignin sulphonic acids represent a wide spectrum of molecular sizes, some of which are undoubtedly very large because of condensation during and after removal from the wood.

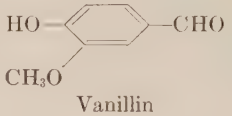
The sulphonic acid group of lignin sulphonic acid is aliphatic for it is unattacked by acid but rather readily removed by alkali.

The reducing sugars present in the liquor vary in identity with the wood pulped. Using a mixture of 85% western hemlock and 15% white fir, a typical furnish for western pulp mills, the sugars present are as given in Table II (*1*). Contrary to what one might expect, glucose is not preponderant.

The pulping industry is almost unique as a user of less than 50% of its raw material. As a consequence, huge quantities of spent sulphite liquor are available for utilization. The sulphite pulping operations in the United States produce annually about 2,500,000 tons of pulp while simultaneously producing around 2,800,000 tons of waste solids.* To put this another way, an average sulphite mill of 200 tons of pulp per day capacity each day produces approximately 4,000,000 lb. of spent sulphite liquor containing 10% solids. It is apparent that a tremendous potential of useful organic materials is available.

The challenge which spent sulphite liquor presents as an inexpensive, large volume raw material has not been ignored. There are an estimated 2000 patents on its use. Unfortunately not more than a handful of these have proved themselves of any commercial value.

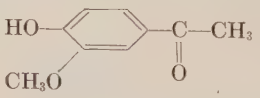
Of the successful processes, first let us consider vanillin production. About 1 million lb. of this chem-



Vanillin

ical are produced annually, and at present it virtually all comes from the alkaline breakdown of lignin sulphonic acid. Up until a year ago about half was made via guaiacol, but the producer has recently built a plant using lignin sulphonic acid. So, for this particular use, spent sulphite liquor is the best raw material (*2*). The yields of vanillin as made in the plant are low, although processes (*3–10*) described in recent patents may change this picture. As presently made, however, the yearly vanillin production must not represent the utilization of more than 30,000,000 lb. of spent sulphite liquor solids, or about 0.5% of that produced annually in the United States. The present production capacity for vanillin is at least large enough to supply the existing market.

Concurrently with vanillin is produced a small amount of acetovanillone and one company is offering it for sale. However, no extensive market for this



Acetovanillone

material (*11*) has been reported.

A possible expansion of vanillin requirements may arise from the development of markets for vanillic acid

W. M. HEARON, Assistant Director of Research, Central Research Dept., Crown Zellerbach Corp., Camas, Wash.

* Canada produces a nearly identical amount of spent sulphite liquor.

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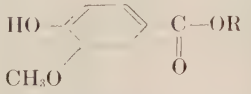
Table I. Composition of Spent Sulphite Liquor (10% Solids)

Basis of 1 ton

Lignin sulphonic acid	128.3 lb.
Hexoses	37.3
Pentoses	5.8
Acetic acid	9.3
Formic acid	1.2
Methanol	2.1
Ethanol	0.35
Furfural	0.58
Acetone	0.35
Inorganics	29.9
Water	1786.0

and its derivatives. Recently a simple and inexpensive



Esters of Vanillic Acid

way was discovered to convert vanillin to its corresponding acid (*12–14*) a reaction not easily carried out by the obvious methods. Pearl (*15*) has furthermore made an extensive study of vanillin and vanillic acid derivatives. Some of these show considerable promise for commercialization. The esters of vanillic acid are effective antimycotics (*16*, *17*). Ethyl vanillate is a specific for histoplasmosis and coccidioidomycosis (Valley Fever), and is a good preservative for several foods (*18*). Recently Pearl (*19*) reports that the ether

Ether Esters of Vanillic Acid

esters are even more effective than the esters as fungicides. Ethyl vanillate has also been found to absorb those rays in the ultraviolet region which cause sunburn while transmitting the "tanning" rays (*20*, *21*). The application of this information to the preparation of a suntan lotion is obvious.

Although the sugars present in spent sulphite liquor are not the major constituent, they are available at a sufficiently low cost to allow their use as a raw material for fermentation. One plant is operating in the United States on spent sulphite liquor and produces ethyl alcohol at a rate of about 10,000 gallons per day.† This process is presumably a profitable one despite the fluctuation in the price of alcohol. Perhaps a major consideration in this operation is that the plant was constructed during World War II for defense supplies and represents a totally amortized investment. Without such an incentive other sulphite producers have not considered alcohol production from spent sulphite liquor a promising venture.

Another process for the utilization of the spent sulphite liquor sugars is the manufacture of yeast. After a careful pilot-plant period, small-scale production of yeast has been started by a Midwestern paper company (*23*). Reports on their efforts show that a market does exist for the yeast primarily as an animal feed supplement (*24*). There appear to be no major problems in the process. Another paper company is starting construction this year on a 4500 tons-per-year yeast plant from spent sulphite liquor (*25*).

Vanillin, alcohol, and yeast represent specific products derived from spent sulphite liquor. This is one approach to the problem of successfully utilizing the liquor.

It is not, however, the only approach possible, nor the only one which has been successful. There are two other ways: (1) to concentrate the liquor and sell the concentrate or to dry the concentrate and sell a solid product and (2) to modify part or all the liquor constituents to a new product of relatively unknown composition but having properties of commercial value.

The producers of vanillin, alcohol, and yeast have not neglected this aspect either. Each is offering for sale the lignin residues from their process. A definite market exists for these products as additives to cement, ingredients in adhesives, and extenders of tannins. Apparently the markets for the products derived from the spent sulphite liquor and the markets for the lignin residues are reasonably in balance at the present time.

About half a dozen companies are currently either concentrating or drying their spent liquor solids and marketing them under their own trade names. No accurate figures are available as to the amount of material sold in this form, but it is probably in the order of 100,000 tons annually or less than 4% of that produced in the United States.

Basically spent sulphite liquor has two properties which account for most of its uses. The first is its dispersing action attributable to the lignin sulphonic acids present. Almost anywhere that an inexpensive dispersing agent is needed, these spent sulphite liquor products will be effective at least to a degree. Specifically they are used for dispersing carbon black in the rubber industry, cement slurries, clay and gypsum, as ingredients in detergents, asphalt emulsions, insecticide wettable powders, for boiler water treatment, and as a dye leveling agent.

The second property is its binding action. This is evidenced in the use of these spent sulphite liquor products in linoleum cements, coal briquettes, as foundry core binders, ceramic binders, and road binders.

Besides uses as a dispersant and binder, a few others should be mentioned. Some spent sulphite liquor products are used as extenders for the natural tannins in tanning. Some have also been used as additives for oil well drilling muds. Small quantities are used in storage batteries. A report was made recently that the United States Department of Agriculture has found some soil conditioning action of spent sulphite liquor (*26*). A recent patent covers the use of the liquor in copper plating baths (*27*). Spent sulphite liquor has also

Table II. Sugars in Spent Sulphite Liquor[a]

Sugar	*Proportion of total sugar, %*
Mannose	48
Glucose	15
Xylose	15
Galactose	10
Arabinose	6
Fructose	<2
Unaccounted for	4

[a] 85% western hemlock, 15% white fir pulped. Mulvaney, Agar, Peniston, and McCarthy, *J. Am. Chem. Soc.*, 73: 1255–1257 (1951).

† Another alcohol plant operating on spent sulphite liquor was built in Canada during the Second World War and is still operating (*22*). Sulphite mills in Europe have produced alcohol from their liquor for many years, but there the economics are favorable.

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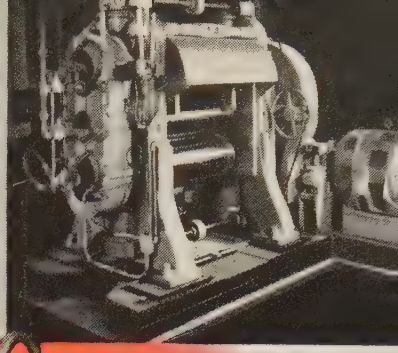

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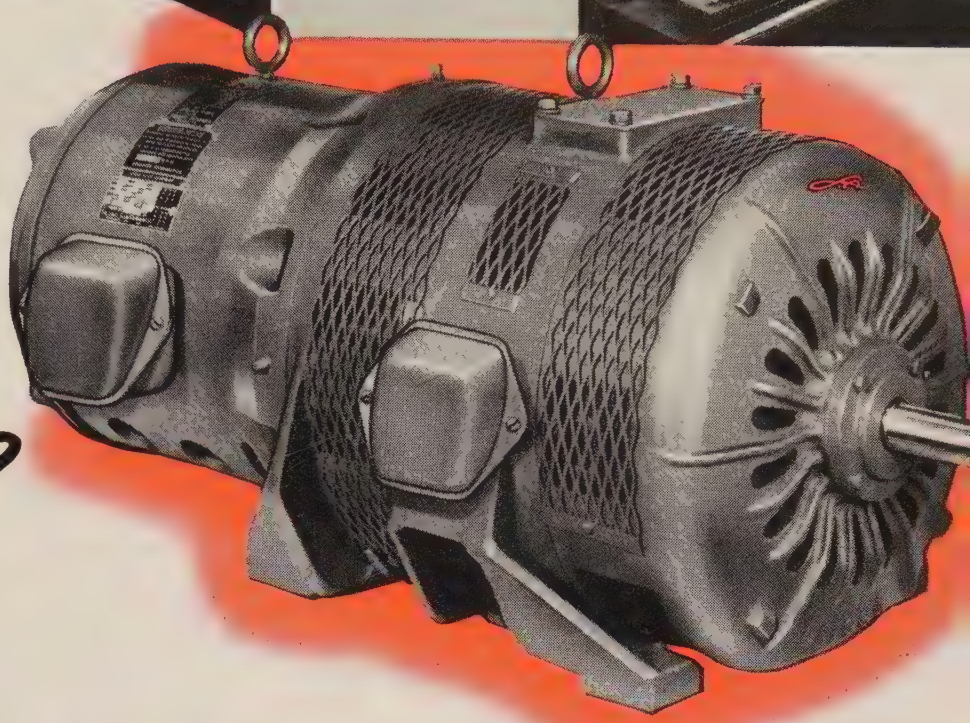

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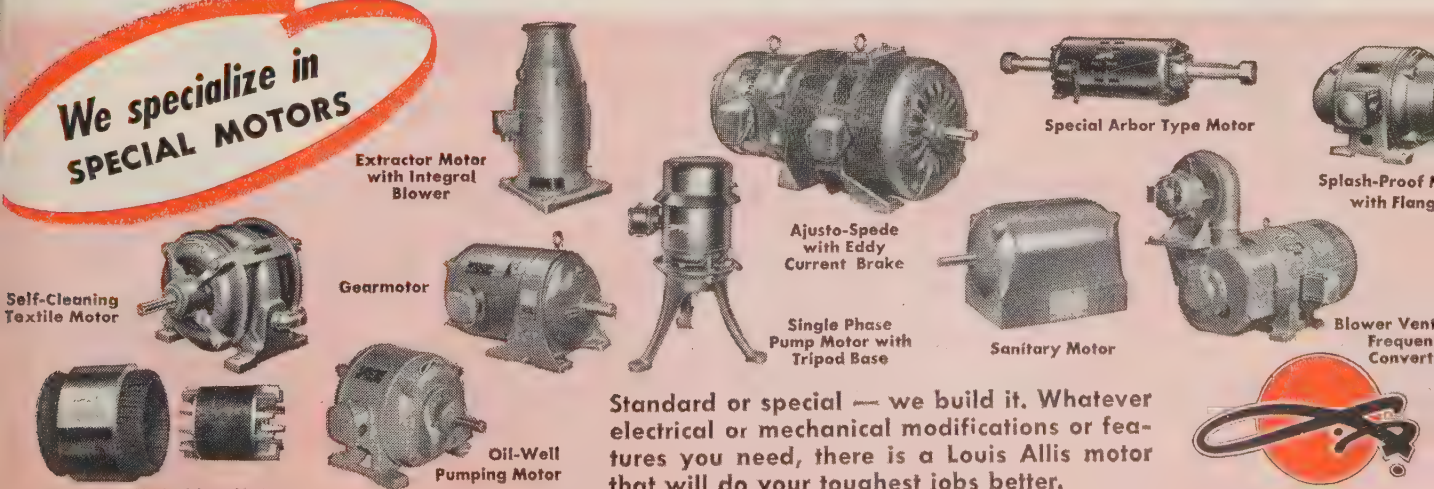

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been reported in Canada and Europe to precipitate protein from whey (*28, 29*). The product is stated to be satisfactory as an animal food supplement. Another specific use for the liquor is claimed recently as an ingredient in metal pickling baths (*30*).

These whole liquor products vary to a degree in effectiveness depending upon the pulping operation from which they were derived and minor changes in their method of manufacture. However, they are roughly equivalent. One exception to this is a product made from ammonia-base pulping operations which has the unique property of becoming water insoluble on heating. This effect is advantageous for several binding uses.

The Howard process for precipitating lignin sulphonic acid from spent sulphite liquor as the basic calcium salt has been used effectively by one United States organization to produce lignin free of sugars. This Howard lignin is sold as such and is used as a starting material for altered lignin products "tailor-made" for a particular application (*31–33*). This has been a highly successful approach.

These products from Howard lignin represent examples of modifications of part or all of the liquor constituents to produce new products for sale. However, several other new compositions of matter from the liquor are beginning to find use.

By an alkaline treatment and reaction with an aldehyde, the liquor is converted to a product having thermosetting properties according to a recent patent (*34*). The application of this preparation to the plywood and hardboard fields appears indicated.

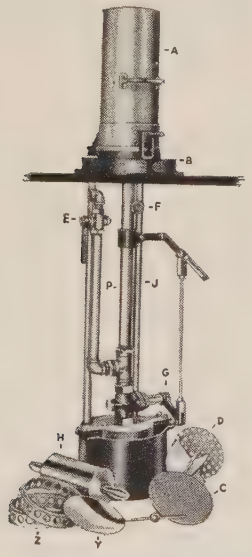
Another resinous product from spent sulphite liquor made with quarternary ammonium bases and salts has been recently patented (*35*). In a similar manner, another patent (*36*) in 1950, reported the precipitation of a lignin sulphonic acid-protein complex on wood material to make molded articles. This last process is being presently exploited. The molded articles apparently are particularly good for electrical insulators (*37*).

Compositions of spent sulphite liquor with polyvinyl alcohol have very good properties as wettable adhesives (*38–42*). One company has been successful in producing a gummed tape with this formulation, while another is marketing the adhesive as a dry powder for other applications.

A recent Canadian patent (*43*) by a Norwegian company describes a process for converting the liquor to a cation exchange resin. Use is made of the condensation of lignin sulphonic acid by acids to an insoluble material while retaining the sulphonic acid groups.

The reaction of spent sulphite liquor with chromates to produce gels and insoluble products has been known for many years (*44*). However, a year ago considerable publicity was given to a modern application of this reaction to the solidification of soil (*45*). The work was performed at Cornell University for the U. S. Air Force. This application could represent a sizable utilization of spent sulphite liquor if the previously limiting difficulties of water susceptibility and structural weakness have been overcome.

Much work is being actively carried out in the United States to find more about the properties and uses of spent sulphite liquor. The National Council for



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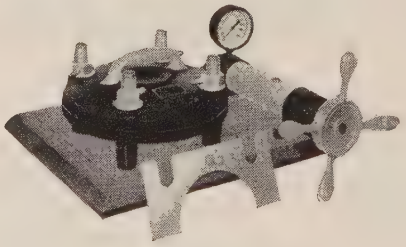

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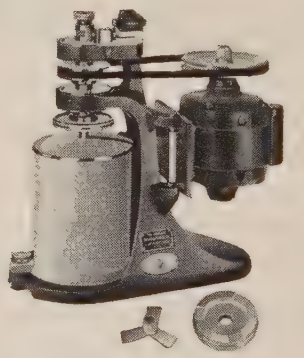

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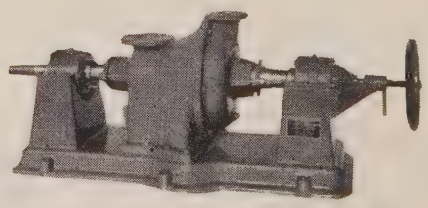

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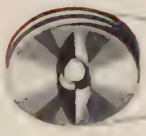

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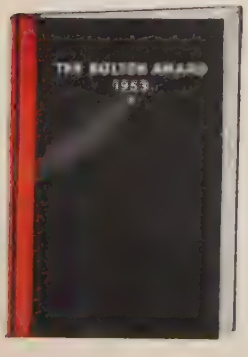

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Stream Improvement, The Institute of Paper Chemistry, the University of Washington, Oregon State College, the Forest Products Laboratory at Madison, Wis., the Brooklyn Polytechnic Institute, the University of Maine, and the Northeastern Wood Utilization Council at New Haven, Conn., are particularly active. In addition almost all the large sulphite pulp producers have aggressive research programs to find means for profitable utilization of the liquor.

Because finding more and more profitable uses for spent sulphite liquor requires long-range technical effort, most sulphite pulp producers are turning to other means for the time being to dispose of the liquor. Most of these disposal practices, however, will allow the ultimate use of the liquor.

Several sulphite pulp producers are evaporating and burning their liquor as a means for its disposal. This operation may be looked upon in one sense as a utilization since the heat values are at least in part recovered. Such utilization of the liquor has been considered for many years but only recently has much research shown the way to evaporate calcium-base liquor without excessive evaporator scaling, and to burn the high ash concentrate while controlling the fly ash. Because ammonium-base liquors, in contrast, can be safely evaporated and easily burned, a trend toward conversion to the ammonium base is occurring.

One way in which more liquor will probably find use is by the discovery of new compositions having properties of value in commerce. The ever-expanding chemical industry provides us each year with new materials some of which may give new and useful spent sulphite liquor preparations. The successful polyvinyl alcohol-waste liquor preparations could not have been possible 25 years ago. In addition, we are living in an expanding market so that even previously known preparations may now find markets. The chrome-lignin process of Cornell University is perhaps an example of this.

Possibly the largest potential for the liquor, however, is as a raw material for the production of pure organic compounds. Vanillin and alcohol need not be the only such chemicals. Perhaps new techniques in hydrogenation or pyrolysis, or new catalysts will be the key to new economically attractive processes.

The basic materials for a new chemical industry are in spent sulphite liquor. Perhaps the efforts of further research will realize this goal.

LITERATURE CITED

1. Mulvaney, Agar, Peniston, and McCarthy, *J. Am. Chem. Soc.* 73: 1255–1257 (1951).
2. Anon., *Chem. Week* 71, No. 11: 55–56 (1952).
3. Fisher and Marshall, U. S. pat. 2,576,752 (Nov. 27, 1951); Can. pat. 467,552 (Aug. 22, 1950).
4. Fisher and Marshall, U. S. pat. 2,576,753 (Nov. 27, 1951); Can. pat. 467,553 (Aug. 22, 1950).
5. Fisher and Sankey, U. S. pat. 2,576,754 (Nov. 27, 1951); Can. pat. 467,554 (Aug. 22, 1950).
6. Marshall and Sankey, U. S. pat., 2,516,827 (July 25, 1950); Can. pat. 470,915 (Jan. 16, 1951).
7. Marshall and Sankey, U. S. pat. 2,544,999 (March 13, 1951); Can. pat. 482,191 (April 1, 1952).
8. Anon., *Can. Chem. Processing* 36, No. 11: 58, 60 (1952).
9. Salvesen, Diddams, Brink, and Owzarski, U. S. pat. 2,434,-626 (Jan. 13, 1948); Can. pat. 478,555 (Nov. 13, 1951).
10. Shoeffel, U. S. pat. 2,598,311 (May 27, 1952).
11. Marathon Corp., *Chem. Processing* 14, No. 1: 18 (1951).
12. Pearl, U. S. pat. 2,441,839 (May 18, 1948).
13. Pearl and Beyers, *Ind. Eng. Chem.* 42: 376–379 (1950).
14. Fortess and White, U. S. pat. 2,547,920 (April 10, 1951).
15. Pearl, *J. Am. Chem. Soc.* 74: 4593–4594 (1952); *cf.* previous papers in this series.
16. Pearl and McCoy, *J. Am. Chem. Soc.* 69: 3071–3072 (1947).
17. Pearl and Beyer, *J. Am. Chem. Soc.* 71: 1066–1068 (1949).
18. Pearl and McCoy, *Food Ind.* 17: 1458–1461 (1945).
19. Pearl and Beyer, *J. Am. Chem. Soc.* 74: 3188–3190 (1952).
20. Pearl, *J. Am. Chem. Soc.* 71: 2331–2333 (1949).
21. Pearl, *Am. Perfumer Essent. Oil Rev.* 56: 25–28 (1950).
22. Joseph, *Sewage Works J.* 19: 60–69 (1947).
23. McGinn, *Paper Trade J.* 133, No. 10: 96, 98–100 (1951).
24. Wiley, Dubey, Leuck, and Hughes, *Ind. Eng. Chem.* 42: 1830–1833 (1950).
25. Anon., *Chem. Week* 71, No. 22: 13 (1952).
26. Annett and Stobo, *The Paper Ind.* 34, No. 9: 1111 (1952). See also, Neller and Kelly, *Soil Sci. Soc. Am., Proc.* 14: 212–215 (1949).
27. Hull and Gray, Can. pat. 485,632 (Aug. 12, 1952).
28. Nilsson, Kyl., *Lantbruks Högskol. Ann.* 17: 1–5 (1950) (in English).
29. Hare and Baker, *Can. J. Technol.* 29: 332–336 (1951).
30. Plump and Carroll, Can. pat. 486,583 (Sept. 16, 1952).
31. Salvesen, Harmon, and Browning, U. S. pat. 2,491,832 (Dec. 20, 1949).
32. Salvesen and Harmon, U. S. pat. 2,505,304 (April 25, 1950).
33. Salvesen and Browning, U. S. pat. 2,533,632 (Dec. 12, 1950).
34. Uschmann, U. S. pat. 2,585,977 (Feb. 19, 1952). See also Borišek and Polčin, *Chem. Zvesti* 5: 322–330 (1951).
35. Ehrensperger, U. S. pat. 2,594,302 (April 29, 1952).
36. Holzer, U. S. pat. 2,534,908 (Dec. 19, 1950).
37. Holzer, Swiss pat. 250,268 (June 1, 1948).
38. Bruce and Heise, U. S. pat. 2,443,889 (June 22, 1948).
39. Bruce and Heise, U. S. pat. 2,544,585 (March 6, 1951).
40. Fenn, U. S. pat. 2,579,481 (Dec. 25, 1951).
41. Fenn, U. S. pat. 2,579,482 (Dec. 25, 1951).
42. Fenn, U. S. pat. 2,579,483 (Dec. 25, 1951).
43. Andersen, Can. pat. 481,243 (Feb. 19, 1952).
44. Haage, Ger. pat. 228,721 (1908). Traner and Haage, U. S. pat. 969,504 (1910).
45. Hough and Smith, *Paper Trade J.* 133, No. 24: 40 (1951); *Ind. Labs.* 3, No. 1: 73 (1952); *Chem. Eng. News* 30, No. 1: 74, 76 (1952).

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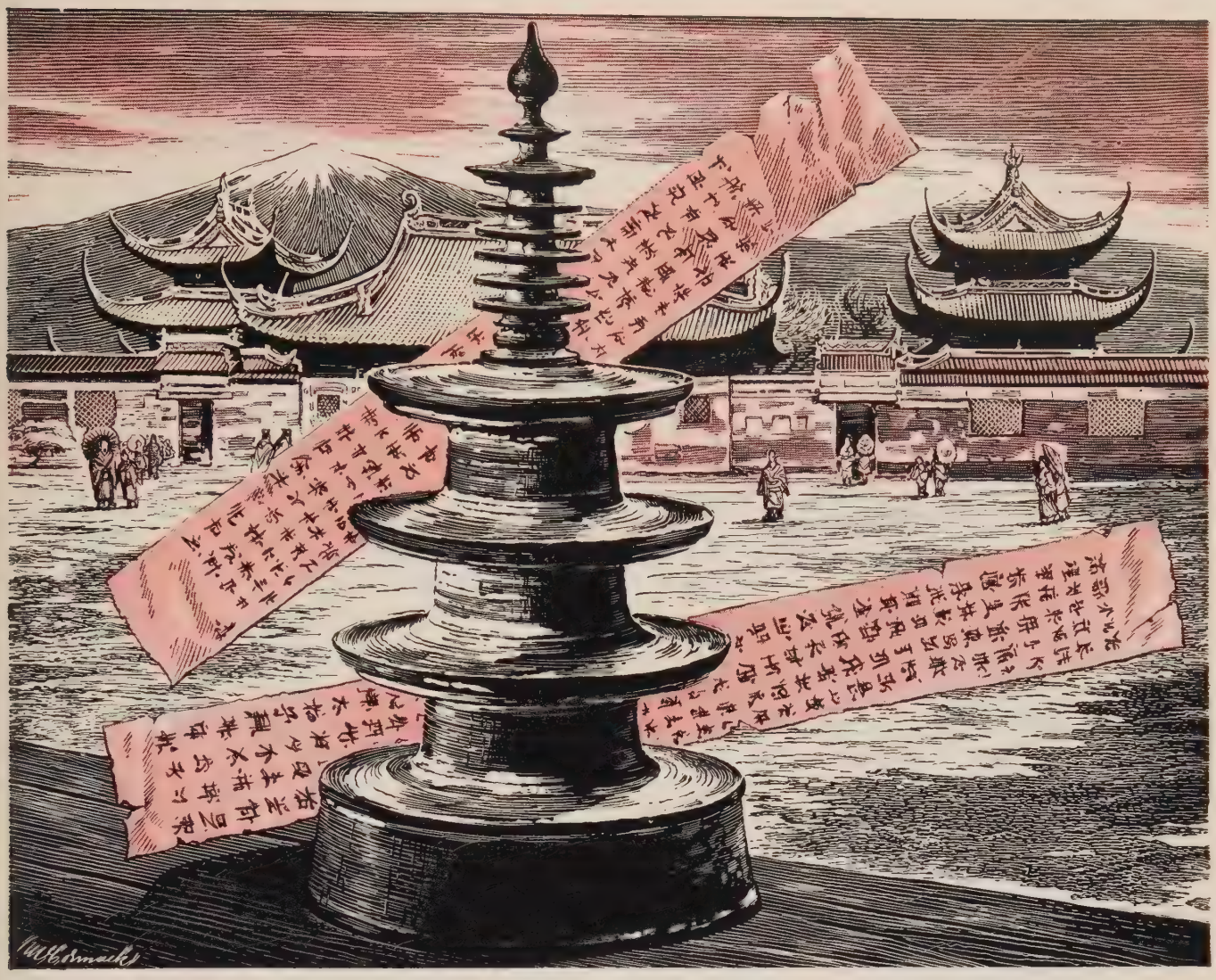

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Better Pulpwood Costs for the Small Operator

ROBERT H. VAN VOORHIS

A small operator field in which costs are, more often than not, neither at hand nor practicable of development by the producer, is presented here, with description of the steps and physical conditions of the process, together with the potentials for control which lie just beyond rule-of-thumb management. The question is raised as to the source from which control data should be made available.

THE typical producer of pine pulpwood, operating on a small scale, does not employ a cost accountant. Indeed, he operates with a bare minimum of accounting records of any sort. But, in the aggregate, pine pulpwood production is an important business. A substantial investment in southern pulp and paper mills depends upon a continuous flow of this basic raw material. These mills, in their constant search for more economical ways of obtaining their pulpwood, have experimented extensively with mechanical harvesting and handling methods. The benefits of these experiments have been passed along to their wood producers. In addition, many have helped their wood producers to set up accounting records for payroll and tax purposes. A few have developed wood harvesting cost data and records designed to help wood producers in reaching managerial decisions.

The present study is based on the experience of a pulpwood producer whom we shall call Lou Pine, since that was not his name. Pine was an independent contractor, using a mechanized pulpwood mill together with the required auxiliary equipment. He obtained both technical operating assistance and help with his accounting and cost problems from the large pulp and paper mill in South Carolina to which he sold his wood. Although his operation ultimately proved unsuccessful Pine's cost problems were typical of the industry, while the help he received with them points the way toward a very desirable and mutually profitable form of cooperation between wood producers and pulp mills.

TIMBER SOURCE AND MECHANIZED MILLING

One of Lou Pine's first problems was to obtain standing timber to cut into pulpwood. He might buy from any private landowner but, because of his limited capital, he almost always operated on "company" land, owned by the mill to which he sold the pulpwood. Pine operated as an independent contractor, rather than as a company employee. He contracted to buy the standing timber at a fixed amount per unit (168 cu. ft.) of wood, payable when the pulpwood was received at the company mill.

In harvesting the timber, crews fell the trees, using hand or power saws. Other workers trim the branches and cut off the tops with axes. The trimmed trees are fastened to a caterpillar tractor which skids several tree-length logs per trip to a deck adjacent to the pulpwood mill. The mechanized pulpwood mill is the heart of Pine's operation, and distinguishes it from other methods of harvesting pulpwood. The mill is a Rube Goldberg-like machine. It has a power take-off which first winches a log from the storage deck to a small dolly on rails. On the dolly, the log moves under the cut-off saw, which the operator swings down to cut off bolts of the proper length. As they fall from the saw, these bolts land on a chain conveyor which carries them up and over the machine and drops them onto a waiting truck. Thus the series of operations from stump to truck is almost entirely mechanized, with tractor, winch dolly, and conveyor handling the logs through the successive stages.

DELIVERY OF PULPWOOD AND SETTLEMENT

From the pulpwood mill, loaded trucks move through the woods over a crude logging road to a public road, which may not be much better. These roads may become impassable in wet weather and the entire operation may have to shut down. Movable sections of plank road may be brought into use over soft spots or during prolonged rainy seasons. These may enable the operation to continue, but only with the increased cost resulting from the construction, placing, and removing of the plank road sections. Trucks haul the wood directly to the pulp mill from logging chances within a radius of approximately 30 miles. At the mill, truck loads are scaled to determine the quantity of wood. Payment to the producer is based on this measurement, as is the deduction for "stumpage" (the price paid for the standing timber) if the wood was cut from company land. After scaling is completed, the trucks are unloaded mechanically. When many trucks arrive at the mill woodyard simultaneously, there may be considerable delays in scaling and unloading.

Wood harvested beyond the truck haul distance is taken to a convenient railroad siding and placed on freight cars by employees of the producer. The producer is usually paid the same price for his wood, whether he delivers it to the mill yard or places it f.o.b. railroad car at the siding. In one case, the producer bears the expense of the longer truck haul. In the other, he pays for shifting the wood from truck to railroad car. The mill pays the unloading cost for truck wood and pays the freight on rail wood.

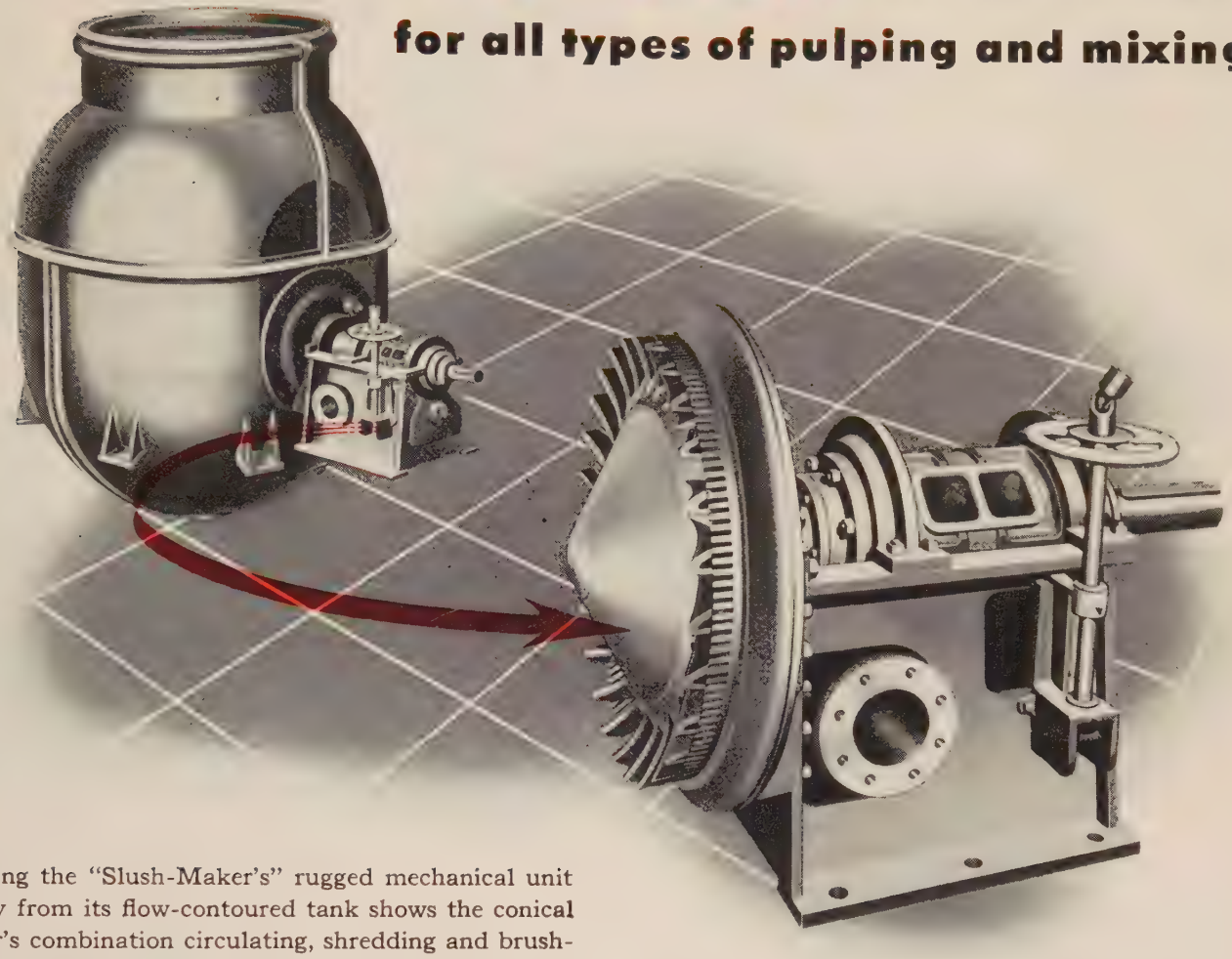
Payment is made to the producer weekly by the pulp mill for wood received at the mill by rail or truck. Deductions are made for stumpage if the wood has been cut from company land, and for any other items as agreed. Advances are sometimes made to the producer for wood in transit by rail. The pulp mill often finances the producer in his purchases of equipment, making deductions at the established rate each week for each item. These payments may become burdensome any week that a small volume is produced.

ROBERT H. VAN VOORHIS, Associate Professor of Accounting, University of Alabama, Tuscaloosa, Ala.

Morden-ize

WITH A Morden "SLUSH-MAKER"

for all types of pulping and mixing



Pulling the "Slush-Maker's" rugged mechanical unit away from its flow-contoured tank shows the conical rotor's combination circulating, shredding and brushing blades, and bars on the stationary attritioning ring

Rapid initial disintegration is given by the rotor's shredding blades.

The positive-flow circulation, across the rotor's face, continually directs the partially broken material at right angles against the bed plate ring.

A hand wheel controlled setting of the rotor assembly can bring the bars on the back of the rotor blades into a brushing contact with the bars on the bed plate ring. This bar-to-bar brushing, when required, will quickly and completely clear all flakes and bundles—even high wet strength—without damage to the fibers.

The Morden "Slush-Maker" also thoroughly mixes and brushes in color, size and other materials in a matter of seconds.

The "Slush-Maker's" side mounted rotor quickly and efficiently slushes full charges of pulp, broke or waste paper, either batch or continuous.

Let us know your slushing requirements and we will gladly analyze how you can Morden-ize your pulping and mixing advantageously.

MORDEN
STOCK PREPARATION EQUIPMENT
MACHINES COMPANY

Corbett Building, Portland, Ore.

OPERATIONS: PERFORMANCE AND RECORD

There was little flexibility in the labor required to run Pine's operation. He needed several teams of fellers and trimmers to prepare the tree length logs. There was a choker setter to attach the logs to the tractor, and a tractor driver. One man was kept busy unhitching the logs from the tractor at the storage deck, hitching individual lengths to the winch and securing them to the dolly. A skilled operator (who doubled as job foreman) ran the pulpwood mill. One helper, in addition to the truck driver, was on duty to help position the wood falling off the machine conveyor onto the truck. If wood were being hauled to a railroad siding, a crew was kept there to transfer the wood from truck to railroad car. A minimum of five pulpwood trucks with drivers were required to carry away the output of the pulpwood mill. More trucks might be required, depending on the length of the haul and the time required to unload.

Pine determined the break-even point on his operation to be 16 units of pulpwood per day. With this in mind, he set a standard of production for use in a simple incentive pay system for his workers. Each type of worker was paid his basic day rate when total production was below standard. When daily production reached or exceeded standard, each worker received a somewhat higher day rate. No individual task standards were set. The team nature of the operation (and worker group pressure) was relied upon to insure individual effort. Breakdown of the tractor or pulpwood mill might result in failure to meet standard production through no fault of the crew but, in general, this form of incentive payment proved beneficial both to Pine and his workers. Time records were kept by the job foreman (or by Pine himself) in an ordinary printed time book. Employees were paid weekly by check.

DAILY OPERATIONS REPORT

Date .....

1. Pulpwood Mill Operation

Start	Stop	Hours	Remarks:
.....	.....	.....	
.....	.....	.....	
.....	.....	.....	
.....	.....	.....	
Total Hours			

2. Tractor Operation

Start	Stop	Hours	Remarks:
.....	.....	.....	
.....	.....	.....	
.....	.....	.....	
.....	.....	.....	
Total Hours			

3. Truck Operation

Truck No.	Trips: 1	2	3	4	5	6	7	8	9	10	Total Miles
.....											.....
.....											.....
.....											.....
.....											.....
.....											.....
.....											.....
.....											.....
.....											.....

Remarks:

4. Pulpwood Production

Approximate Units (168 cu. ft.) .....
Remarks:

Note: Include costs incurred on pulpwood mill or tractor under "Remarks." Use back of sheet if needed

Report Prepared by .....

Fig. 1

The tractor and pulpwood mill were left in the woods. Trucks were garaged adjacent to Pine's residence and drivers checked in and out at that point. Other workers met at the garage or were picked up en route to the job site, where they checked in and out. Everyone took a half hour at noon for lunch.

Since the foreman served as pulpwood mill operator, he was not free to supervise actively the other phases of the operation, but he set the pace through his handling of the pulpwood mill and all other phases of the operation geared themselves to it. Pine, himself, directed the woods work and generally coordinated the activities of the crew, as well as performing all other needed management functions. The foreman prepared a Daily Operations Report (Fig. 1), recording hours worked by the pulpwood mill, hours worked by the tractor, trips made by each truck, and estimated daily pulpwood production. Remarks were listed explaining breakdowns, delays, etc.

As an independent contractor producing pine pulpwood, Pine was subject to the wage and hour provisions of the Fair Labor Standards Act, to the Federal Insurance Contributions Act, and to state and Federal unemployment compensation insurance laws. He was also subject to workmen's compensation regulations. These involved him in the minimum required payroll record-keeping and report preparation. Although neither had any formal training in bookkeeping, Pine or his wife kept these and all other records, working at home.

EQUIPMENT: PURCHASE AND OPERATING COST PROBLEMS

Minimum original cost of the mechanized pulpwood mill, tractor, trucks, saws, and other tools required for Pine's operation ran between 20 and 30 thousand dollars. The pulpwood trucks could be expected to last about 2 years, the tractor and pulpwood mill perhaps twice that long. A heavy fixed charge for depreciation resulted. Pine was financed in his equipment purchases by the pulp mill to which he sold his wood. By agreement, fixed amounts for each item of equipment financed were deduced from his weekly check for wood received at the mill. This out-of-pocket charge had to be met before Pine could get funds to pay his labor and other operating expenses. Equipment costs were thus a heavy fixed item.

Operating in open woods and on logging roads, with heavy loads, trucks had relatively high maintenance costs. Tires were especially subject to damage, being frequently snagged on roots or stumps. Truck operation cost varied according to the road surface, heaviest cost per mile being incurred while operating through the woods and on logging roads and lowest costs on paved highways. These factors made it difficult to control equipment operation costs, since no two logging chances are just alike with respect to hauling conditions. Terrain and average skidding distances affected tractor skidding costs. Once set in place, the pulpwood mill is little affected by location, although its performance

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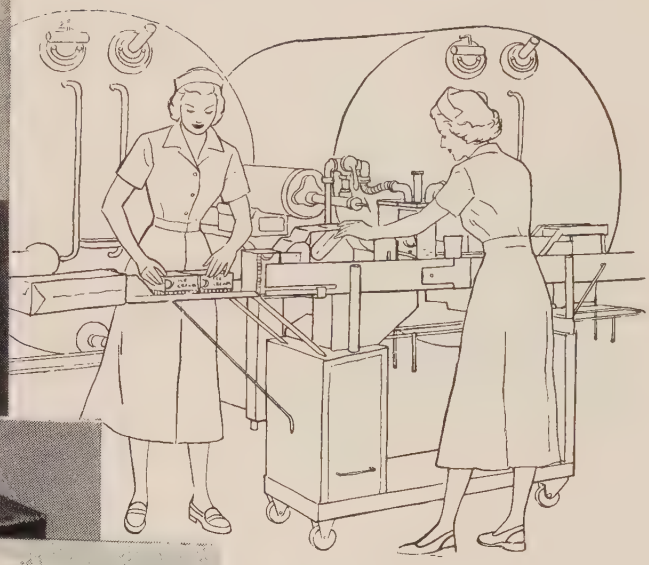

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- ☐ Cartons, ice cream
- ☐ Chewing gum
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- ☐ Drinking cups
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will suffer if adequate quantities of logs are not provided for it. Saws and axes required frequent sharpening and periodic replacement. Distance of the logging chance from repair facilities caused repair costs to vary on any item of equipment. Idle time became particularly important when the tractor or pulpwood mill was down.

A recurring but irregular item was the cost of moving the pulpwood mill to a new location when the timber on a logging chance had been cut. The total cost of the move, including costs of bringing plant road sections in and taking them out again, was a sunk cost which had to be recovered from the proceeds of timber cut and sold from the new logging chance.

All this indicates the importance of recording and controlling equipment operation costs, but the operators, and even Pine himself, lacked both the ability and the inclination to keep and analyze records. In fact, many of the truck drivers could neither read nor write. Under these conditions the records had to be as simple as possible. To accumulate truck operation costs, each driver was provided with a stout envelope into which he was required to place delivery tickets received with each purchase (on account) of gas or oil, each repair or other expenditure incurred for his truck. These envelopes were picked up at the end of each week and their contents summarized by Pine or his wife to determine actual costs for each truck for the week. Delivery tickets were filed for comparison with monthly statements from vendors. The daily operations report listed the number of trips made each day by each truck. Since hauling distance was constant for each setting of the pulpwood mill, total mileage run was readily ascertained by multiplying the number of trips by the round-trip mileage. Hours run by tractor and pulpwood mill were also recorded on the daily operations report. The foreman kept track of the operating costs under the remarks section of the same form.

RULES-OF-THUMB NO SUBSTITUTE FOR COST DATA

Pine's operation was essentially a single-department, single-product one with no in-process inventory problems, lending itself to the simplest process cost accounting techniques. In fact, by accumulating total costs and dividing by total units of pulpwood produced in any period, Pine could determine his average cost of production. Comparing the mill price for wood with this figure gave Pine his average profit or loss per unit produced. This, of course, was interesting in retrospect, but not particularly helpful to him in managing his business.

Because of his day rate basis of paying his labor, Pine had no exact standards for its accomplishments. Timber cost was uniform per unit of wood received at the pulp mill. This tended to encourage Pine to be wasteful of the standing timber in the harvesting process and certainly provided no incentive for improved utilization of wood if this involved increasing other costs. The principal opportunity for standards and cost control, lay in equipment operation.

Factors affecting trucking costs included distance from the mill or railroad siding and the portions of this distance to be traversed over various kinds of roads. Cost per mile varied sharply as among logging road, public unpaved roads, and paved highways. Accurate knowledge of these varying costs was very desirable but almost impossible for the small wood producer to develop for himself. The same comments apply to tractor skidding over various surfaces and distances. Mill operating standards and costs presented many problems.

In examining a proposed logging chance, Pine had to estimate what his total cost of logging and hauling would be, add his desired profit, and compare this total with the mill wood price. The difference indicated the maximum amount he could afford to pay for the standing timber. He realized he could not afford to locate on a tract having too little timber to enable him to recover the sunk costs of moving the pulpwood mill or with timber so scattered that he could not keep the pulpwood mill operating above the break-even point. He recognized the risk of operating on low land where operations might become impossible in wet weather or where the costs of plank roads would be excessive. Underbrush, streams, and other natural barriers were also important.

Most successful pulpwood producers have developed rules-of-thumb and a practiced eye which enable them to look over a logging chance and form a fairly accurate estimate of cost and profits possibilities. In addition to increasing the risks of the pulpwood business, such haphazard methods introduce the probability that the landowner will receive less than a fair amount for his timber, since the pulpwood producer will, if possible, provide himself with a safety factor by offering a low price. On the other hand, if competition between producers for standing timber is keen, the producer may increase his offer beyond a reasonable limit and suffer losses which may put him out of business.

Neither extreme is conducive to the most economical operations of the pulp mills. Low stumpage prices reduce the return on their own (often extensive) forest holdings. Operating losses by producers lead to pressure to increase prices paid for pulpwood and may create problems of finding new producers of pulpwood. Losses may be suffered of amounts advanced on the purchase of equipment, if the producers themselves fail.

HOW STANDARD COSTS CAN BE DEVELOPED AND USED

Development of cost standards in pulpwood production is complicated by the fact that each forest situation differs from every other in varying degree. However, each is a composite of factors which can be studied separately and combined appropriately, as is commonly done in developing standards for industrial processes. For example, standard truck operation costs are developed for different types of trucks for both loaded and empty travel over various woods conditions and road surfaces. A given haul is a composite of these various conditions. A standard for it can be estimated by breaking the distance down into its elements and multiplying each by the appropriate standard figure. Similar methods develop tractor skidding costs. Motion and time studies or other common methods can be used in developing standard output and costs for the pulpwood mill and for unloading trucks at the railroad siding.

Various agencies have cooperated in the development of such standards. The U. S. Forest Service, Southern Pulpwood Conservation Association, and many individual pulp mills have participated. D. M. Matthews,

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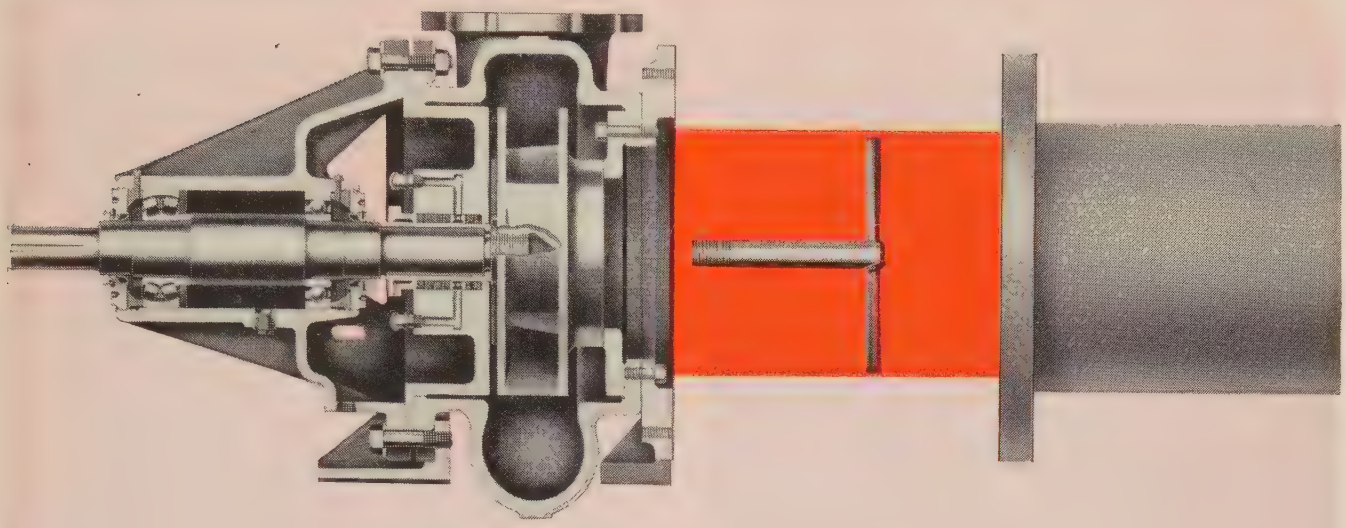

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in his book, "Cost Control in the Logging Industry" (McGraw-Hill, 1942) has published a wealth of figures and methods. Truck and tractor manufacturers have developed performance data on their products. Carefully worked out standards can be of considerable help to a producer in estimating the possibilities of a proposed logging chance and in controlling his operations. Although the average producer cannot develop such data, he could learn to use it with moderate help.

Lou Pine had the benefit of data developed by the company to which he sold his pulpwood. This company had been instrumental in developing and testing the particular pulpwood mill which Pine used, and had experimented over a number of years with the type of mechanized pulpwood production operation which he conducted. Using this information, Pine was able to judge more accurately the probability of success for himself and any given logging chance. The company was better able to estimate what would be a fair stumpage price for its standing timber in various locations. Periodic comparison of Pine's actual results with these expected standards brought to light ways in which Pine could improve his operations. Evidence gradually mounted, however, to indicate that the operating standards developed for the pulpwood mill in the company experimental operations were based on more nearly ideal conditions than could generally be achieved in practice.

Unfortunately for Lou Pine, the pulpwood mill method of harvesting pine pulpwood proved unprofitable as he was able to apply it. Wet weather, frequent breakdown of the pulpwood mill and attendant costly delays, difficulty in handling the woods labor without employment a nonworking foreman, and inability to secure suitable logging chances, coupled with his insufficient capital, ultimately led to Pine's failure and retirement from the pulpwood production field. (The type of of pulpwood mill Pine was using has, incidentally, since been abandoned by the company which developed it.)

STANDARD COSTS AND FOREST ECONOMICS

What, then, does Lou Pine's experience suggest for the use of cost accounting by pulpwood producers? First, that cost accounting (or even basic record-keeping) is difficult for the small operator. Second, that the information cost records would provide could help him to operate more intelligently and more profitably. Third, that realistic cost standards could be even more useful than historical costs for management planning and control.

Who will develop these standards? Certainly not Pine and his fellow producers. They are not trained for such work and their long and hard daily toil in the woods leaves them little time or inclination for it. The problems could be left to various agencies (already doing good work), such as the U. S. Forest Service, state college experiment stations, and colleges of forestry.

Those most vitally concerned with pulpwood production, the large pulp and paper mills, have both the talent and the economic (profit) motive to solve these problems. The author believes they should undertake to do so. Individual firms can carry on the work independently or can pool their efforts through already established trade associations. Company cost accountants and company foresters, working together, can adapt regional data to local conditions. Foresters trained in the use of cost standards can work with individual wood producers in applying cost data to guide them and help solve their problems.

Producers must be shown relatively simple systems of collecting actual cost data (such as the envelopes used by Pine to collect his truck operation costs). Periodic comparisons between actual results and expected standards will probably have to be relied upon for control, rather than continuous standard cost accounting procedures. Better standards in estimating the planning operations should help prevent the economic waste exemplified by Lou Pine's experience.

Forest economics and the development of cost accounting in forestry are becoming increasingly important to users of forest products. As consumers, this includes all of us. In the pulpwood field, foresters employed by trade associations and individual mills, and working with wood producers, must be trained in bringing the benefits of cost accounting and standards to the individual wood producers, without involving these operators in any considerable amount of paper work. This field is relatively untouched.

Cost accountants, particularly those employed by the pulp and paper mills in the south, have here a real challenge and a great opportunity for service with profit to their companies, to the pulpwood producers, to the owners of private timberlands, and finally to all of us, consumers of their products.

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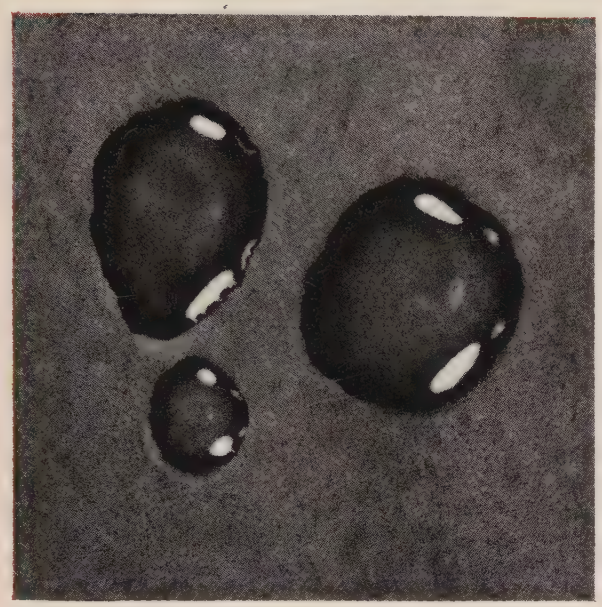
BLOTTER TEST PROVES

Kelsize Solution Controls Penetration of Porous Surface



This unretouched photograph shows a 1% solution of Kelsize twenty minutes after being puddled on blotter. Note how solution remains on surface of blotter. This test illustrates that Kelsize is an excellent material for controlling penetration and strike through of aqueous solutions, thus increasing the efficiency of adhesive or surface sizing solutions by retaining them at the area of application.

Here is unretouched photograph of water, without Kelsize, on piece of same blotter, taken seconds after water was placed on blotter. Note how water has immediately passed into blotter compared to controlled penetration of Kelsize solution. Proof that Kelsize and Kelgin are superior surface control agents and regulate surface density and penetration — precisely and effectively.

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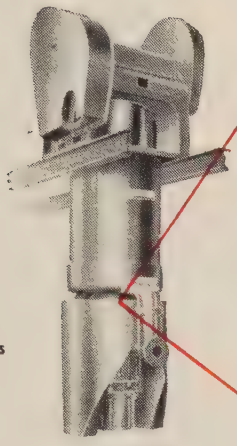
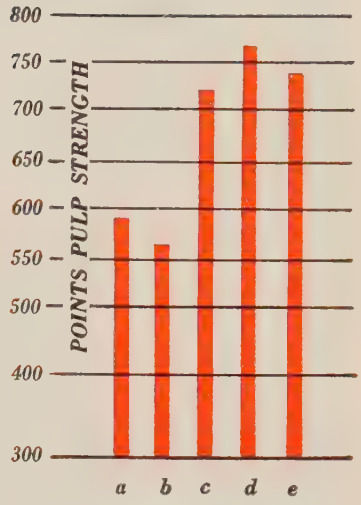
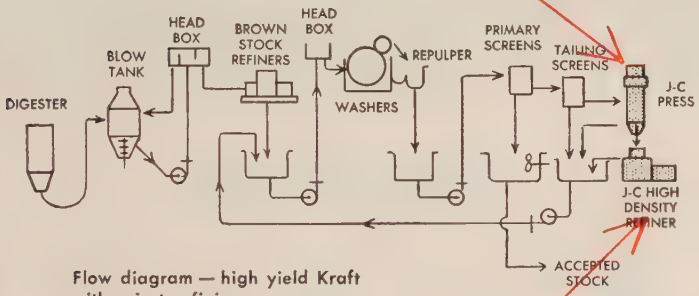


medium size
J-C Zenith Press



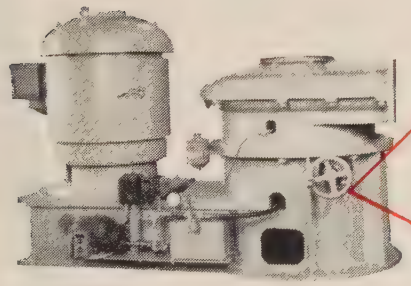
a. 100% rejects — one pass in high density refiner
b. 100% rejects — two passes in high density refiner
c. Normal high yield Kraft pulp
d. 95% C & 5% A
e. 95% C & 5% B

Points pulp strength = 2 × Mullen plus tear. (Note that pulp containing refined rejects is stronger than normal pulp and equal in appearance.)



Flow diagram — high yield Kraft with reject refining

RECENT TESTS PROVE A SUPERIOR PULP RESULTS FROM MIXING A PULP NOW LOST (REJECTS) WITH NORMAL HIGH YIELD KRAFT



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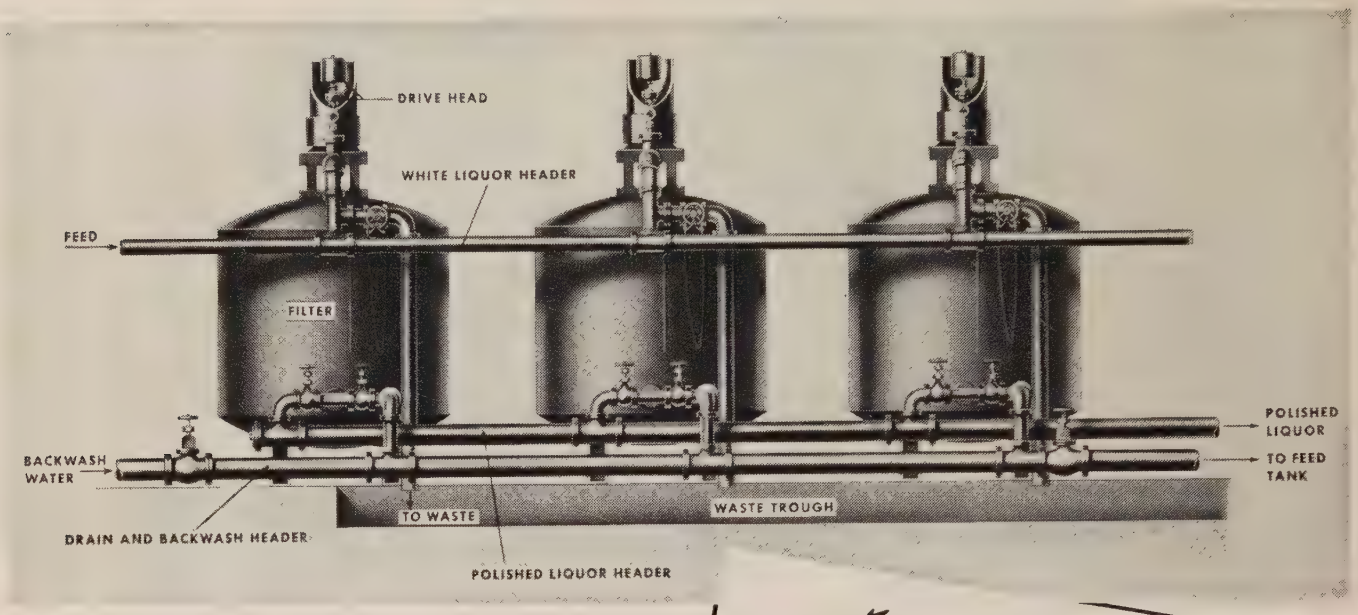

Designed to fit in as an integral part of new or existing Dorr Continuous Recausticizing Systems, the White Liquor Polishing Station consists of one or more vertical pressure filters and all necessary piping, valves and control instruments. While this development is of particular importance to producers of bleached and dissolving pulps, the assurance of a cooking liquor of uniform purity and clarity is of interest to every producer in terms of better overall operation.

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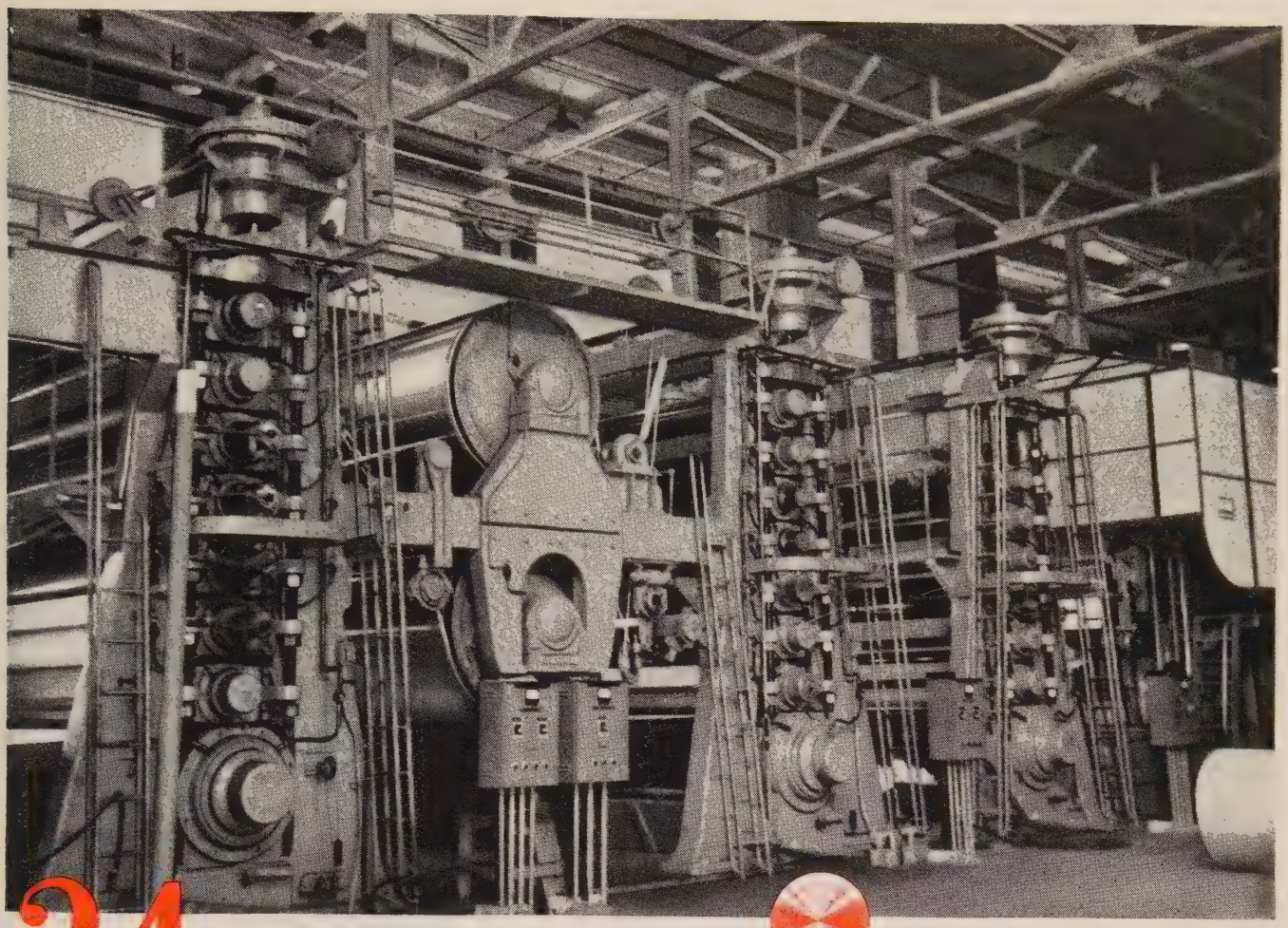

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One way in which Hollingsworth & Whitney has maintained a reputation for producing high-quality papers for over ninety years is by buying the "best" in new equipment.

For example, each of the three calenders in the above photo is equipped with eight Farrel rolls. Although these twenty-four rolls are a small part of the paper machine, they make an important contribution toward producing a uniform, compact roll of paper at the reel.

Farrel rolls are designed to suit individual requirements. They are made of the correct metal formula for the service; with the correct depth and hardness of chill to provide necessary strength and long life; and with the correct amount of crown to compensate for deflection.

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ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
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The 174-inch Fourdrinier machine and the three calender stacks recently installed in the new addition to Hollingsworth & Whitney's Mobile (Alabama) mill, were designed and built by Rice Barton Corporation, Worcester, Mass. Calender rolls were furnished by Farrel.

•

Farrel rolls are made in the world's largest specialty roll shop, in any size from 5" to 72" in diameter and up to 312" face length. For further details, send for a copy of Bulletin No. 116. No cost or obligation.

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production increased up to 15 tons per day...

. . . with W & T chlorination equipment

A Southern mill had been having trouble with paper breaks attributable to the presence of slime in their white water. Despite continued efforts to control them slime breaks were running 60 to 80 per week, resulting in a time loss of 10 to 14 hours per week, and an average production loss of 15 tons per day! It was then that the W&T man was called in. Where and how to apply the proper treatment was determined, the costly methods were discontinued, and W&T chlorination was installed.

During the first 3 days of chlorination the mill recorded only 1 slime break and 2 minutes of lost time.

During the next 3 days there were 4 breaks and 17 minutes of lost time.

During the next 25 days there were no breaks attributable to slime!

. . . Within a week there were no production losses caused by slime! Performance such as that is typical of what your W&T representative can do for you.

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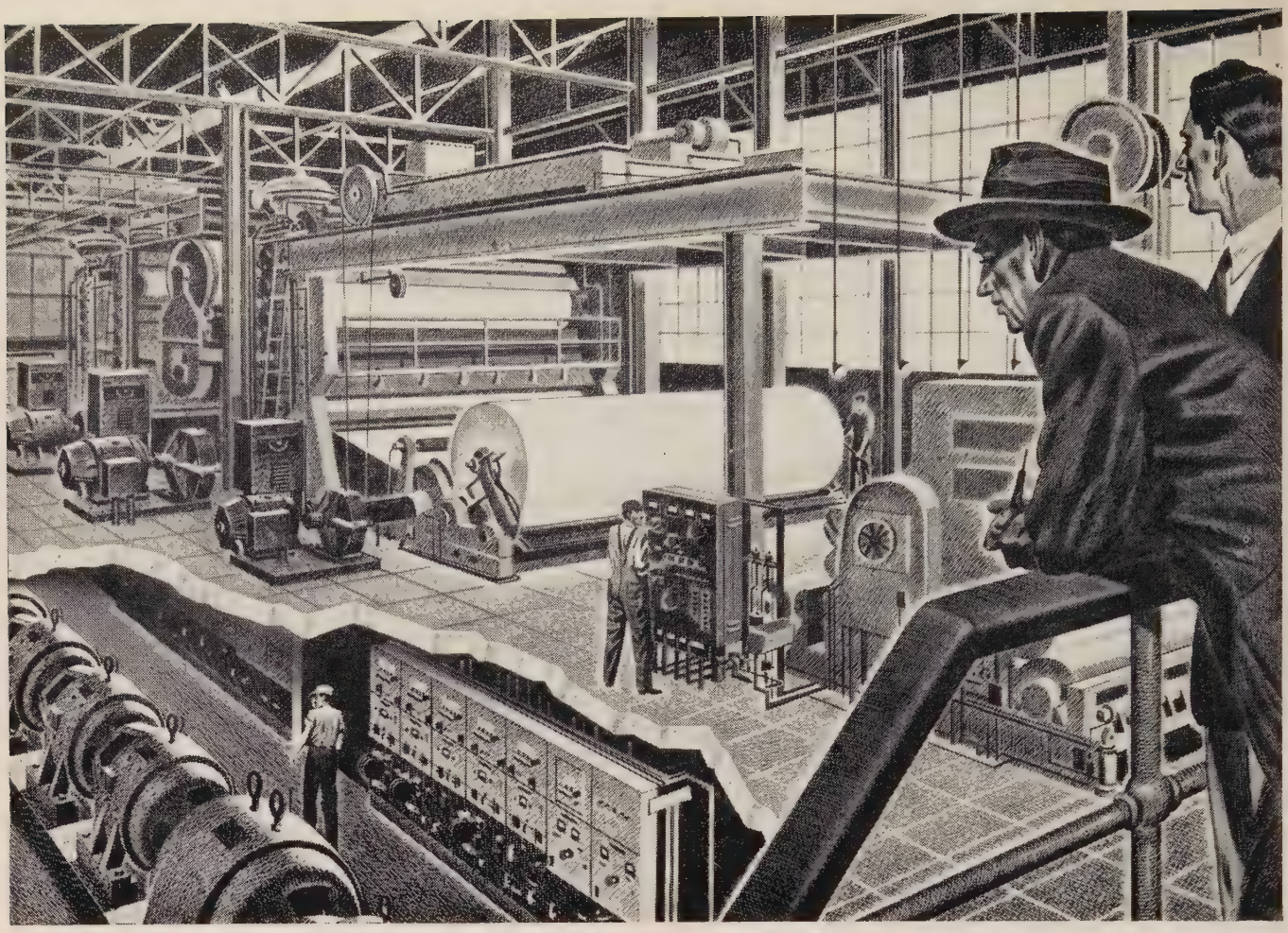

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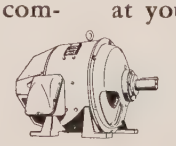

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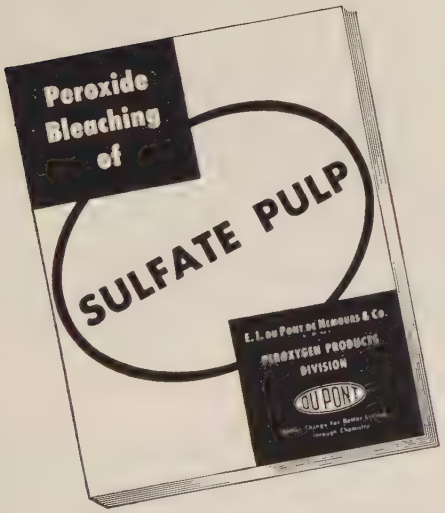

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Bark Removal Methods and Machines

G. E. BELL and P. E. MARTIN

EACH year a large volume of "mill waste" suitable for use as pulpwood is produced in Eastern Canada sawmills, but, for various reasons, only a very small percentage is so utilized. Studies by the Forest Products Laboratory, Ottawa, show that in the manufacture of spruce lumber an average of about 30% of the log volume is sawn into slabs and edgings, unusable as lumber but containing good wood. However, before these slabs and edgings can be used as pulpwood, they generally must be barked and transported to a pulp mill. The economics of these processes are the main controlling factors in determining what mill waste can be profitably used for pulpwood.

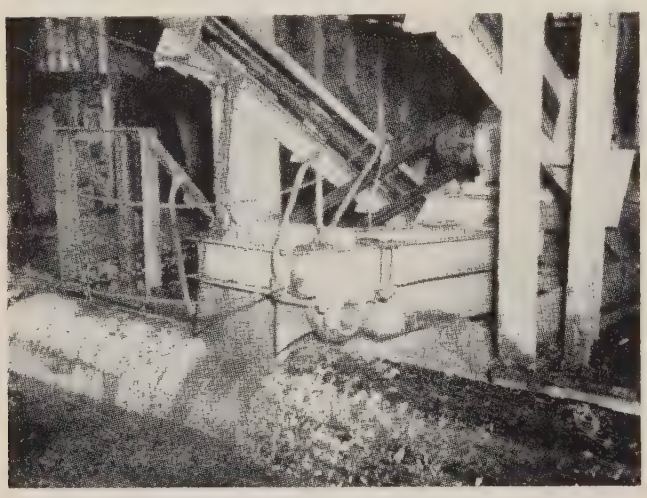


Fig. 1. E. V. Prentice log barker

There are in Eastern Canada about 2000 sawmills sawing spruce and balsam fir. Approximately 1 million cords of slabs and edgings are produced each year as a by-product. In addition, there are many mills sawing other species, some of which are suitable for some types of pulp or for the production of fiberboards. At present, however, only about ten sawmills in Eastern Canada are marketing their slabs and edgings to pulp or board mills.

At present, the most important single use for this by-product is as fuel-wood. This, of course, is a low value use. It is probable that large volumes now used as fuel, destroyed, or discarded could be diverted to the manufacture of pulp with the solution of the problems of barking and hauling.

Three types of barkers are now in use in the sawmills of Eastern Canada. Two of these, the Waterous and the Astrom, bark whole logs, while the third type, the buzz barker is used for slabwood. The Waterous whole log friction barker was developed during the war years and consists

G. E. BELL and P. E. MARTIN, Forest Products Laboratories Div., Dept. of Resources and Development, Ottawa, Ont.

Information assembled by the Forest Products Laboratories Div., Forestry Branch, Dept. of Resources and Development, Canada, for the "Research Coordinating Committee on the Utilization of Mill Waste for Pulpwood. This committee was organized in Eastern Canada in 1951 to coordinate research and development activities in furthering the use of "sawmill waste" for pulpwood.

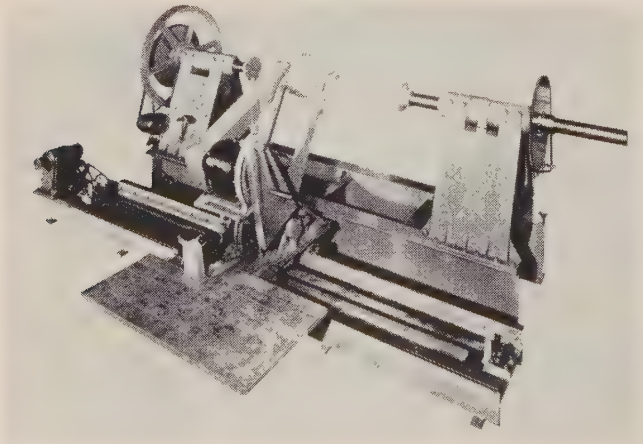


Fig. 2. Globe patented peeler barker

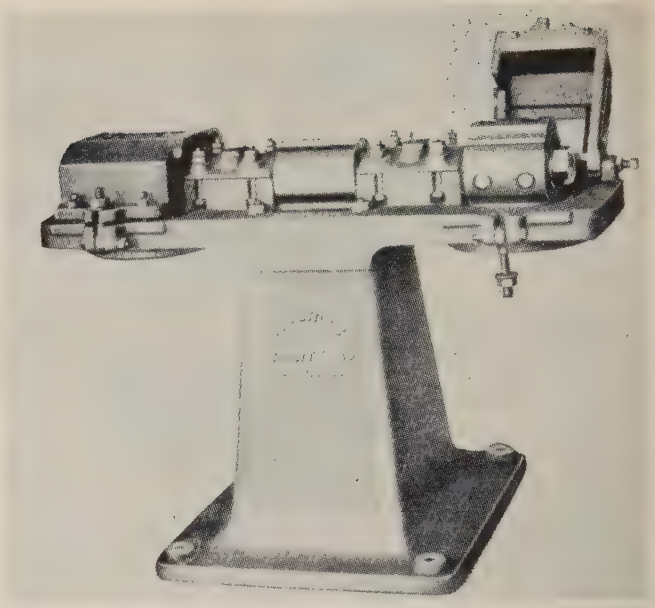


Fig. 3. Barker arranged for belt drive

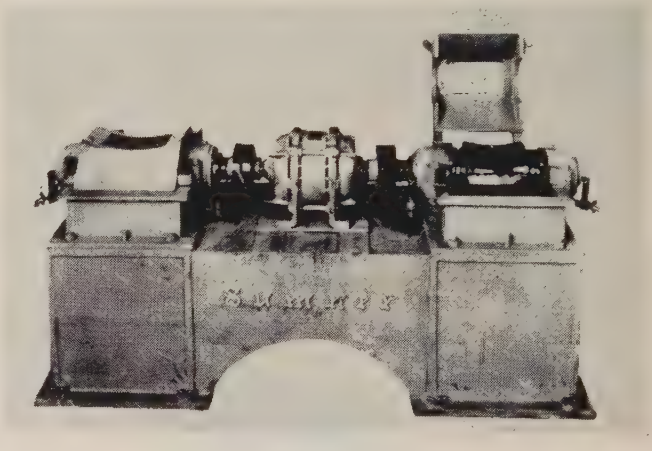


Fig. 4. Electrical slab barker

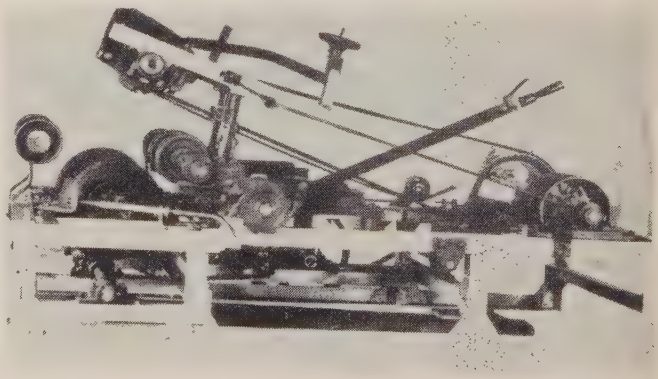
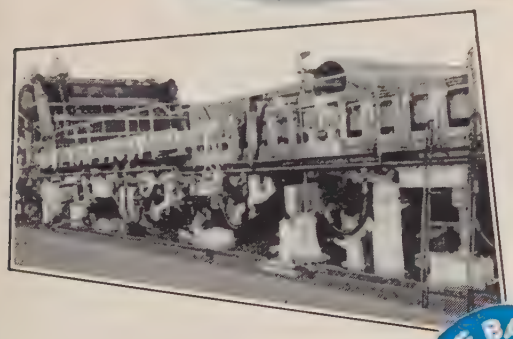


Fig. 5. Crouse portable rosser



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	Waterous friction, whole log	*Astrom (chain barker)*	*Ederer (scraper type)*	*Andersson*	*Drum*	*Nekoosa*	*Lowther*	*Click*
Manufacturer	Waterous Ltd., Brantford, Ont.	American Defibrator Inc., New York, N. Y.	Ederer Engineering Co., Seattle, Wash.	Soderhamn Verkstader, A. B., Soderhamn, Sweden	Waterous Ltd., Brantford, Ont.	Nekoosa Foundry & Machine Works, Inc., Nekoosa, Wis.	Harry A. Lowther Co., Joliet, Ill.	Click Mathewson, Lake City, Fla.
Principle of operation	Logs rub against each other in a hopper. Logs are moved by chains	Barking accomplished by a system of chains rotating around the log while the log itself is moved through these chains without rotating	Air chucks rotate log. Hydraulically controlled scraper blade removes bark. Scraper arm is moved the length of the log on a carriage which has a motorized screw drive. Carriage travels by means of two heavy duty conveyor chains, one on each side to assure even steady movement. Rotating action of the log and pressure of scraper arm removes the bark	The operating principle involves a series of knuckles which are rotated around the rough log as it is fed through the machine. These knuckles are forced against the log by pneumatic pressure, sheating the bark free	Logs rolled in a drum 30 to 45 ft. long. Water is sprayed on to wash bark away	Pulpwood rotates and passes through three rollers; an idler, powered roll with several sets of hammers which strike bark (at the rate of 36,000 times per min. but this may be varied) and a tangential feed roll	Post is manually fed against a rotating cylinder of chains	Post is manually fed against a rotating cylinder of chains. Post passes over drum rather than under as in Lowther
Cost	$30,000 (1947)	$25,000 f.o.b. Bethlehem, Pa. (1951)	Each barker built to meet individual requirements of the purchaser	Five sizes (logs up to 30 in. diam.) $14,451 to $27,873 depending on log diam. capacity desired, f.o.b. a North American port	$51,000 f.o.b. Brantford, Ont. (1947)	$12,500 f.o.b. Nekoosa, Wis. (1951) (includes truck, pneumatic tires, gasoline motor and three lengths of portable conveyor)	$280 with engine f.o.b. Joliet, Ill. (1947)	$450 with engine (1947 U. S.)
Capacity	300 logs or 22 cords per hr.	8 to 12 cords per hr. with regular pulpwood 3 to 14-in. in diam. 8 ft. and up in length	Depends on individual installation	9 to 10 cords per hr. or 237 logs ($7^1/_2$ in. diam. by 16 ft.) per hr.	20 to 40 cords per hr.	5 cords upwards per hr. Logs 3 to 12 in. in diam. 14 or 15 ft. in length	200 to 600 posts per man per day. 7-ft. logs up to 8 in. in diam.	1 to 2 min. per post
Horsepower	175 hp. (total)	1 main driving motor, 40 hp. 1 closing motor 20 hp. 1 opening motor 10 hp. 1 Log feeder motor 10 hp. 1 to 5 hp. motor for drive of bark conveyor	Depends on individual installation	33 hp.	125 hp.	Four-cylinder $30^1/_2$-hp. gasoline engine	6 hp.	6 hp.
Limiting factors	Initial and operating costs. Not applicable to slabwood	Only takes logs up to 14 in. in diam. Logs greater than 8 ft. in length must be fairly straight. High initial cost. Not suitable for slabwood	Not applicable to slabwood	Whole logs only	Initial and operating costs. Suitable for pulpwood only at present	Handles pulpwood only	Will handle only small poles. Trials have been made for pulpwood but have proved unsuccessful	Will handle only small poles

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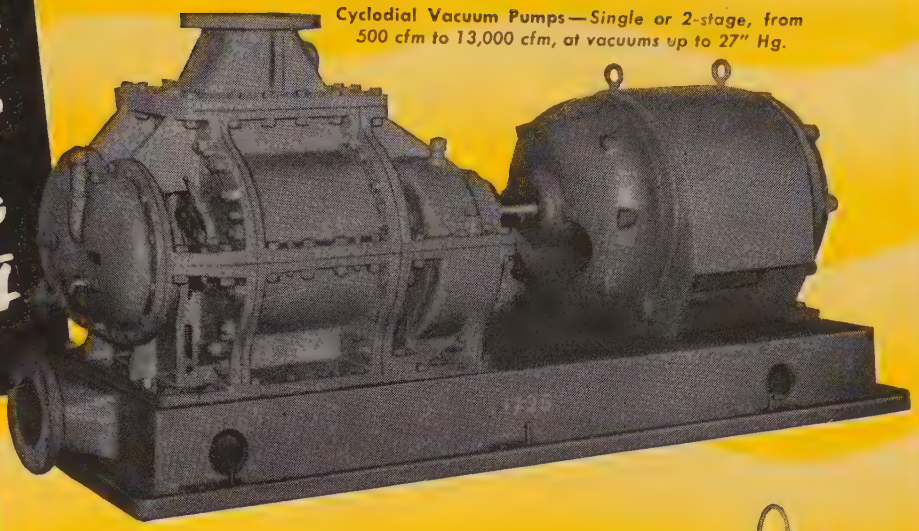

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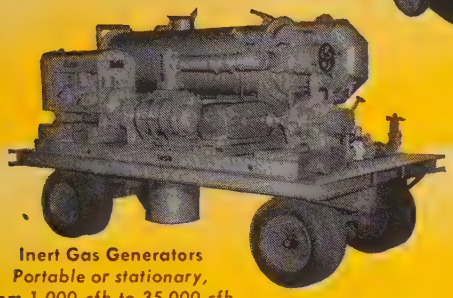

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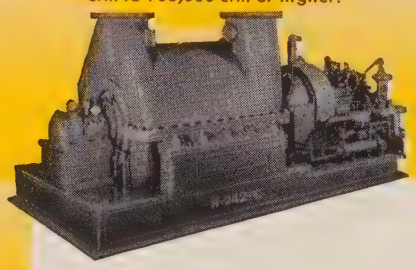

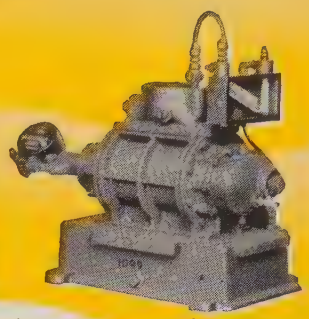

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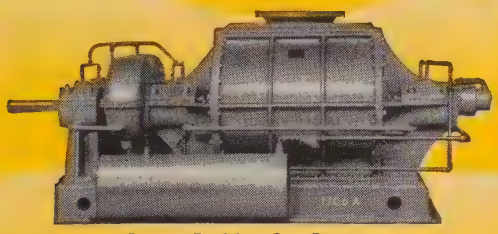
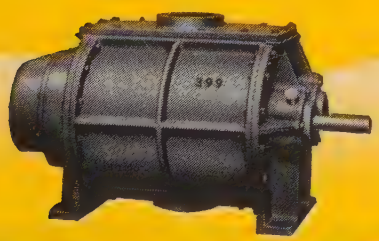


Rotary Positive Gas Pumps
5 cfm to 50,000 cfm.



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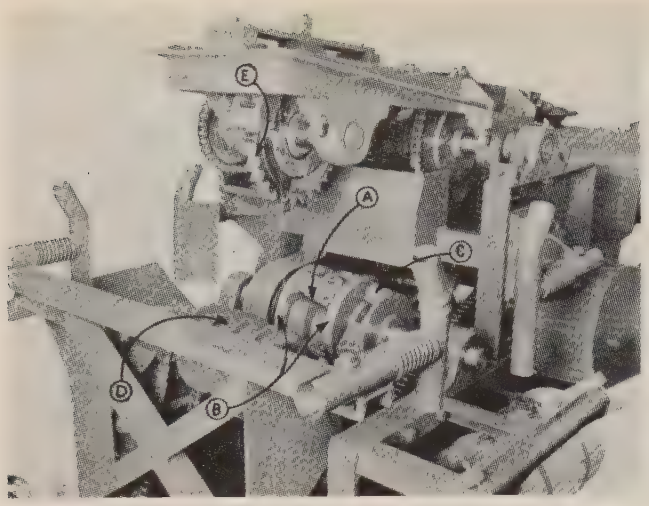


Fig. 6. Peppy peeler

of a large hopper in which about 60 logs are rotated against one another until the bark is removed. The initial cost of this type of barker restricts its use to the larger mills. The first Astrom chain barker to be used on sawlogs in Canada

Fig. 7. Efurd (Hurricane) pole peeler

was installed in 1951. Bark is removed by the action of four chains rotating around the log as the log is fed forward. The high initial cost also limits the use of this barker.

The action of the buzz barker which is used for barking

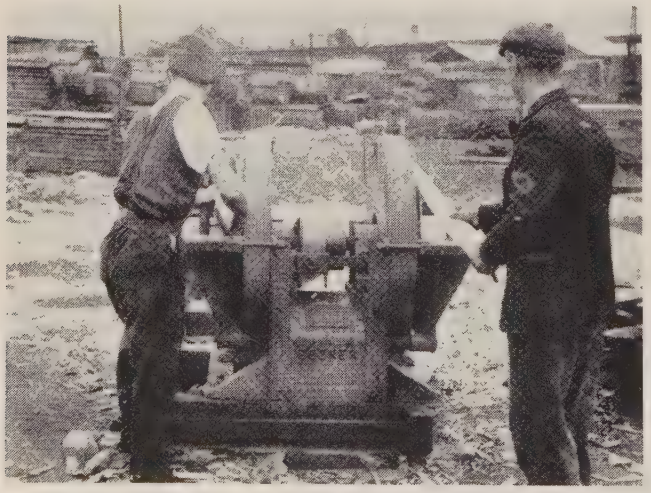


Fig. 8. Bezner pole peeler

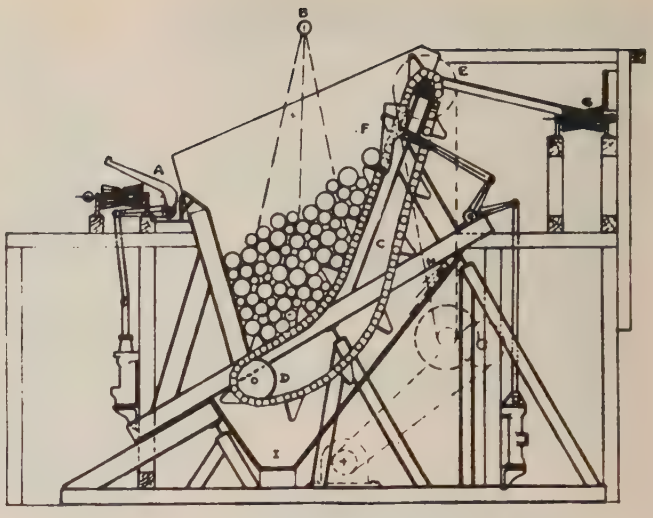


Fig. 9. Waterous whole log friction barker

slabs and edgings resembles that of a buzz planer. A cutter head is mounted on each end of a spindle thus allowing two men to work on one barker at the same time. The cost of this machine is relatively low but the capacity is small about

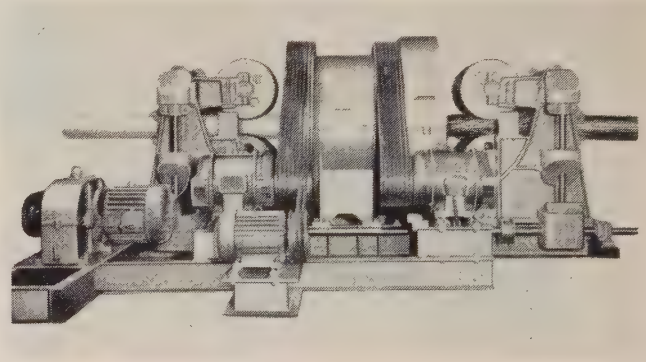


Fig. 10. Astrom barker

2.8 cords per man per day being the production average, and there is some wood loss along with the bark.

BARK REMOVAL METHODS

All barking machines at present in use can be classified into four main groups: those employing (1) cutting knives,

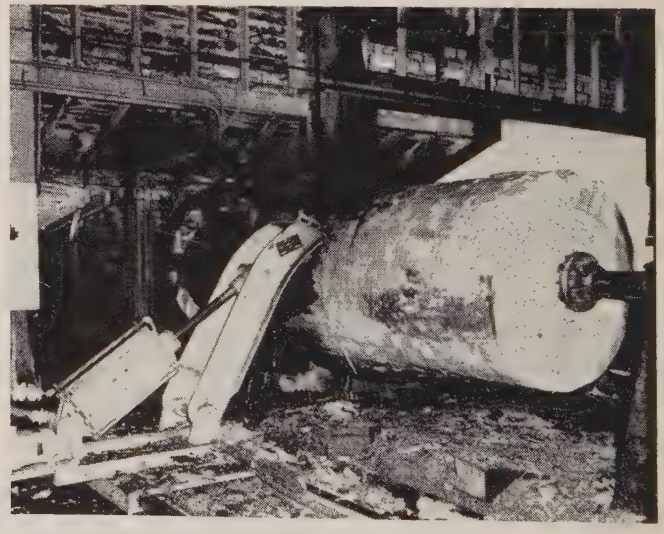
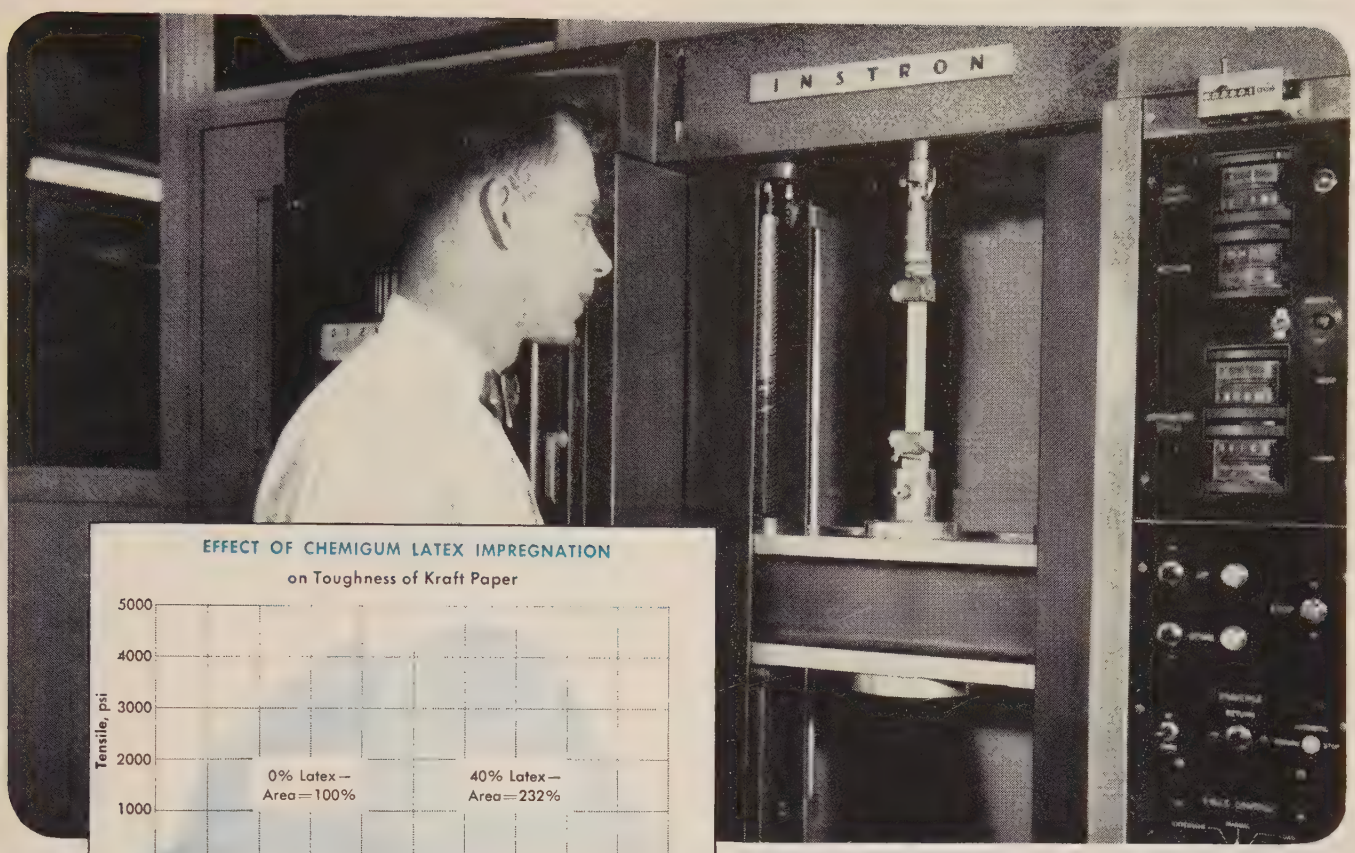


Fig. 11. Ederer scraper—type barker



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	E.V. Prentice log barker	*Globe patented peeler barker*	*Buzz*	*Disk*	*Crouse portable rosser*	*Peppy peeler*	*Efurd (Hurricane)*	*Bezner*
Manufacturer	E. V. Prentice Co., Portland, Ore.	Globe Machine Mfg. Co., Tacoma, Wash.	Waterous Ltd., Brantford, Ont.	Waterous Ltd., Brantford, Ont.	H. L. Crouse Ltd., Bangor, Me. (Creighton & Smith Motors, Fredericton N. B.) (Cdn. agents))	Canadian Vickers Ltd., Montreal, Que.	Efurd Machine & Welding Co., Rossier City, La.	England
Principle of operation	Logs are barked in the water by a 22-blade, 16-in. wide by 20-in. diam. cutter-head with replaceable teeth mounted into the cutting blade. The log is floated to the barker and spiraled past the cutter-head by means of two endless chains. The depth of cut is controlled through adjustable guide shoes mounted on either side of the cutter-head. Refuse bark is removed by blower suction and discharge pipe	Logs are chucked between chuck plates. The log is then rotated and a cutter-head is brought into contact with the perimeter. The cutter-head is then passed across the surface of the log and the bark is removed. The depth of cut is controlled by increasing or decreasing the pressure on the cutter-head	Four knife cutterheads on both ends of a spindle cut the bark. It resembles the action of a buzz planer	Radial knives on a rotating disk remove the bark	Log rotates on idler roller and powered cutting roller (3 knives). Powered toothed wheel pressed on top of log causes it to rotate and feed	Pulp logs rest on a power-driven cutter-head and idler roll, being rotated and fed ahead by powered toothed wheel pressed on top of the log (similar to Crouse portable rosser)	Hydraulically positioned 2-knife cutter-head. Log is fed by powered roller	Rotating disk (similar to disk barker)
Cost	Redwood barker (large size) $56,500 (1951). Fir, pine barker (small size) $49,350 (1951)	No information	$725 (1947)	$900 (1947)	$5000 (small model) $8000 (large model) f.o.b. Presque Isle, Me. (1951)	$4970 f.o.b. Montreal (1951)	$2000 (England 1951)	$250 (England 1951)
Capacity	Logs of diam. 1 to 10 ft. and a maximum length of 20 ft. may be handled. 10 to 16 ft. is the minimum log length depending on size and shape of the log. Redwood production equals 120 M ft. b.m. (Humboldt log scale). Fir, pine type upwards of 120 M ft. b.m. per 8-hr. day	For a maximum log length of 156 in., the minimum diam. log is 4 ft. For a maximum log length of 136 in., the minimum diam. is 28 in.	2.8 cords per man per day (2 men) 8-in. slabs maximum width. Minimum thickness down to mill edgings	Approximately the same as buzz (for large slabs)	15 to 30 f.p.m. Small machine can handle logs 60 ft. long and 18 in. butt. Carriages on either side of machine support log	2 cords per hr.	Poles up to 18 ft. long from $2^1/_2$ to 10 in. diam.	Poles up to 6 in. in diam.
Horsepower	325 hp. (total) for large machine	$54^1/_4$ hp. (total)	5 hp.	Approximately the same as for the buzz barker	10 hp. for softwood. 12 hp. for hardwood	24 hp.	$7^1/_2$ to 10 hp.	6 to 10 hp.
Limiting factors	Not applicable to slabwood	Not applicable to slabwood	Small capacity. 15% wood loss. High labor requirements	Small capacity. Removes some wood High labor requirements	Not applicable to slabwood	Not applicable to slabwood	Not applicable to slabwood. Handles only small poles	Handles only very small poles

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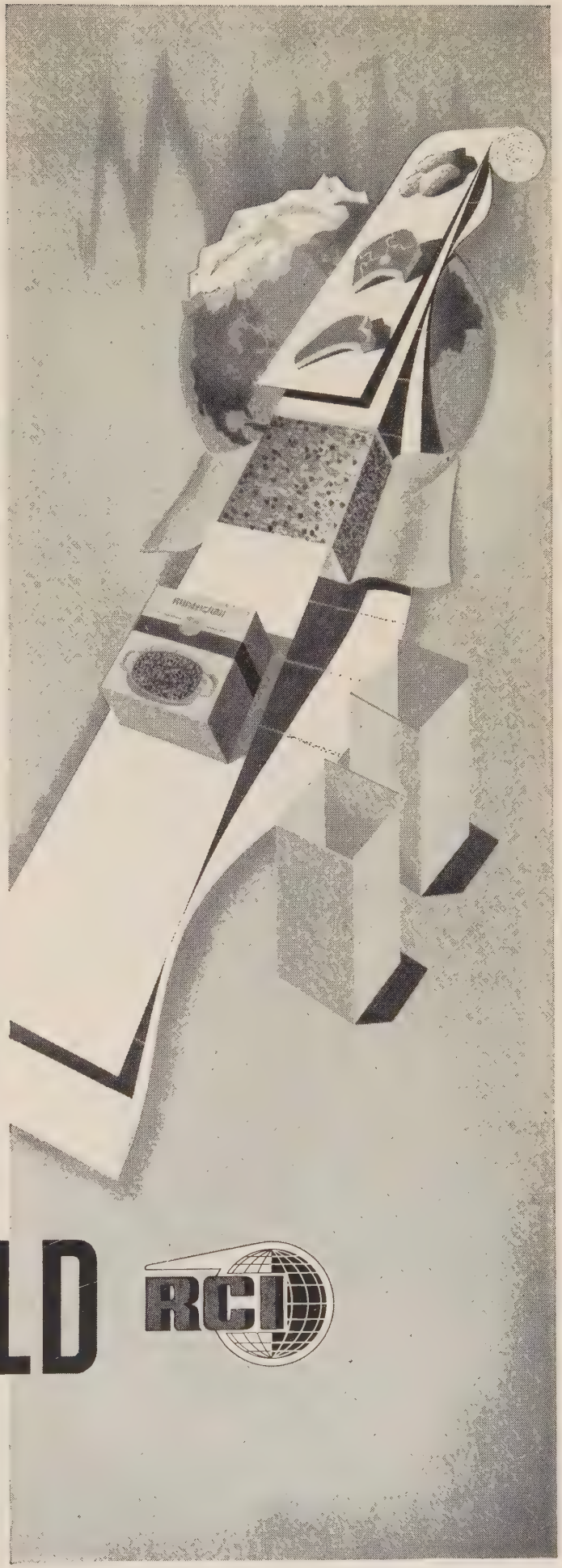


Fig. 12. Andersson pneumatic barker

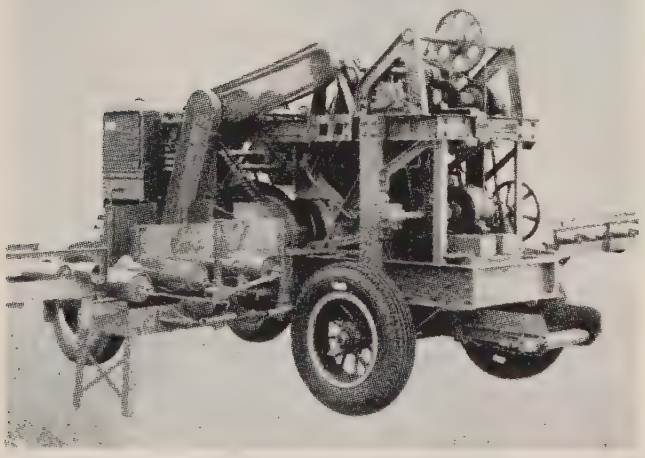


Fig. 13. Nekossa pulpwood peeler

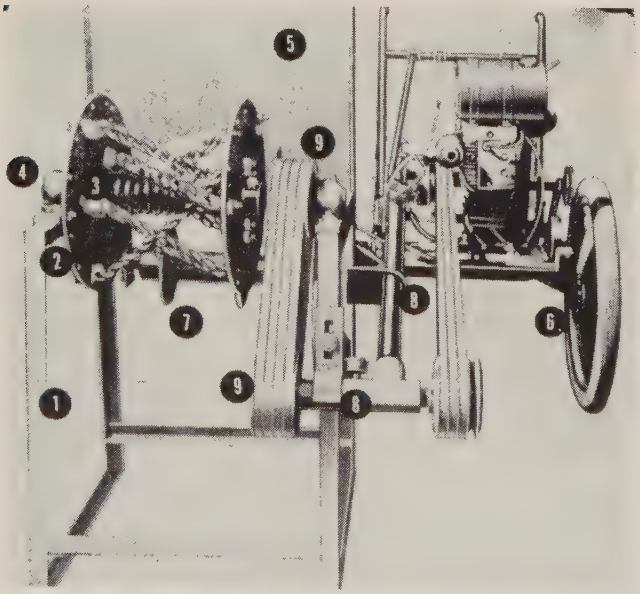


Fig. 14. Lother post peeler

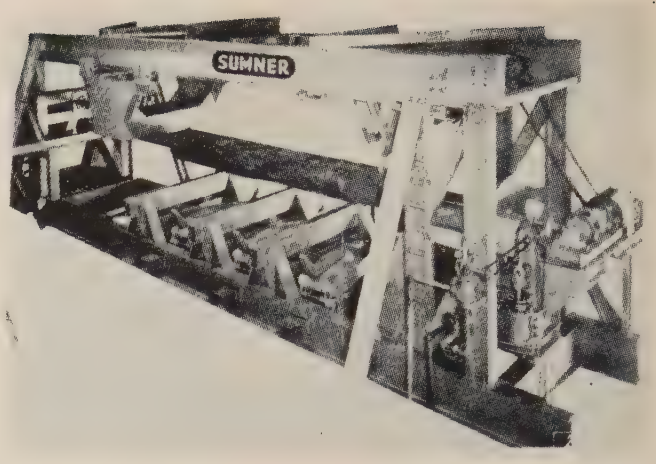


Fig. 15. Zellerbach hydrobarker

(2) rubbing friction, (3) hydraulic erosion, and (4) thermopressure.

Cutting Knives

Eight barking machines are included in this group. All employ some arrangement of knives which cut the bark from the log. As a result of this cutting action, there is some wood loss along with the bark. Most of these machines are designed to handle only small wood such as poles, pulpwood bolts, and slabs, although two machines of this type bark large logs.

Rubbing Friction

Eight barking machines are included in this group, four of which are designed to handle sawlogs while the remaining four handle small pulpwood bolts or poles. Bark removal is

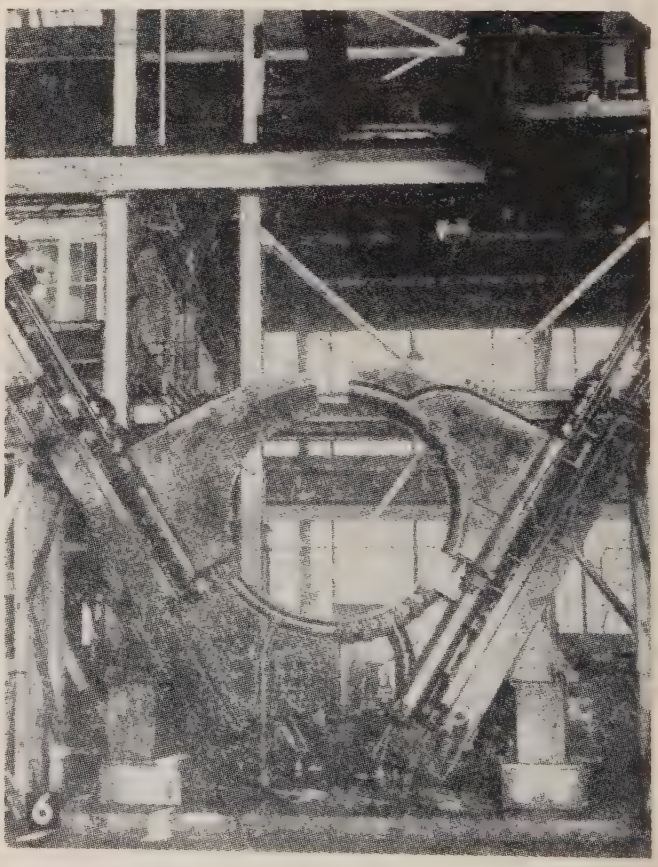
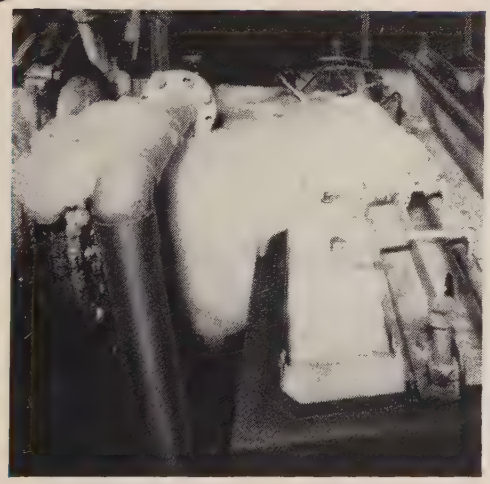


Fig. 16. Worthington hydrobarker

FOAM

beautiful here

but not here



Yes, foam is both decorative and useful in milady's bath, but certainly not in the pulp and paper mill where it retards production and lowers quality.

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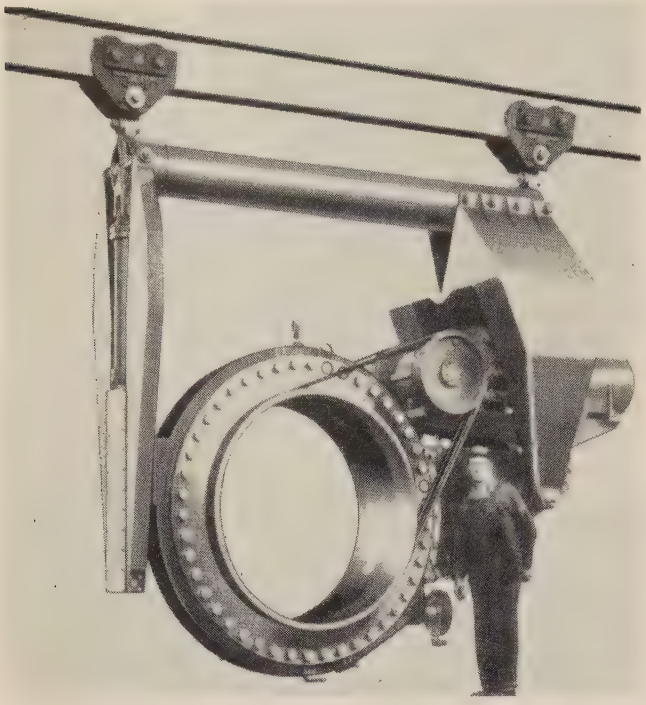


Fig. 17. Hansel ring-type hydraulic barker

accomplished through various arrangements of chains, scrapers, or the rubbing of the logs against one another.

Hydraulic Erosion

Six barking machines are included in this group, all of which are relatively expensive, have high power requirements, and

Thermo Pressure

Logs, slabs, and chips	
Manufacturer	Carthage Machine Co., Carthage, N. Y.
Principle of operation	A number of logs or a quantity of slabs are sealed in a stainless steel gun. Vacuum is drawn and then steam under pressure (200 to 600 p.s.i. depending on the species which is being debarked) is applied. The whole is released very quickly ($1/64$ sec.) and blown from the gun (Mason principle). The bark is literatlly blown off
Cost	Estimated at $3800 or $7600 for a battery of two
Capacity	Six units are reported to produce the equivalent of a drum barker
Horsepower	Reported to be about 6 hp.
Limiting factors	None in commercial production as yet. Still in experimental stages

are designed, with the exception of the hydraulic slab barker, to handle relatively large logs. The actual barking operation is accomplished through the action of a stream, or streams, of

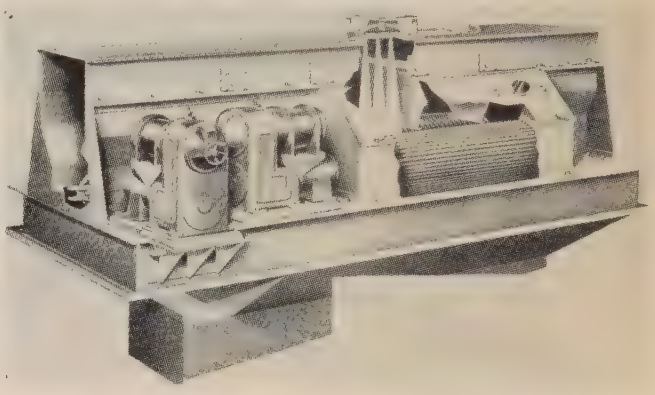
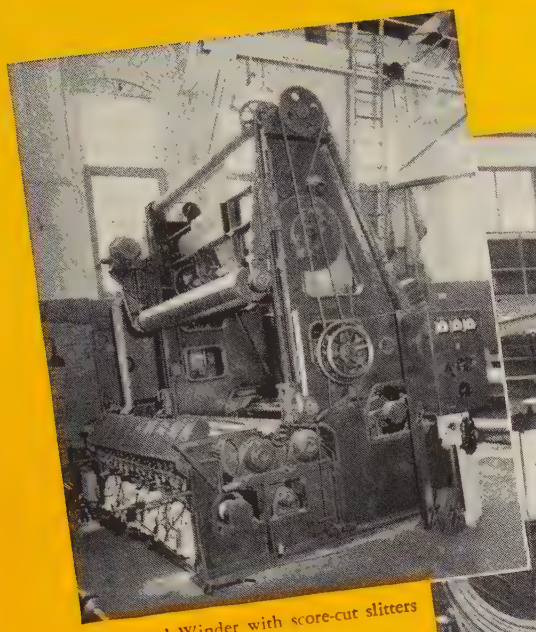


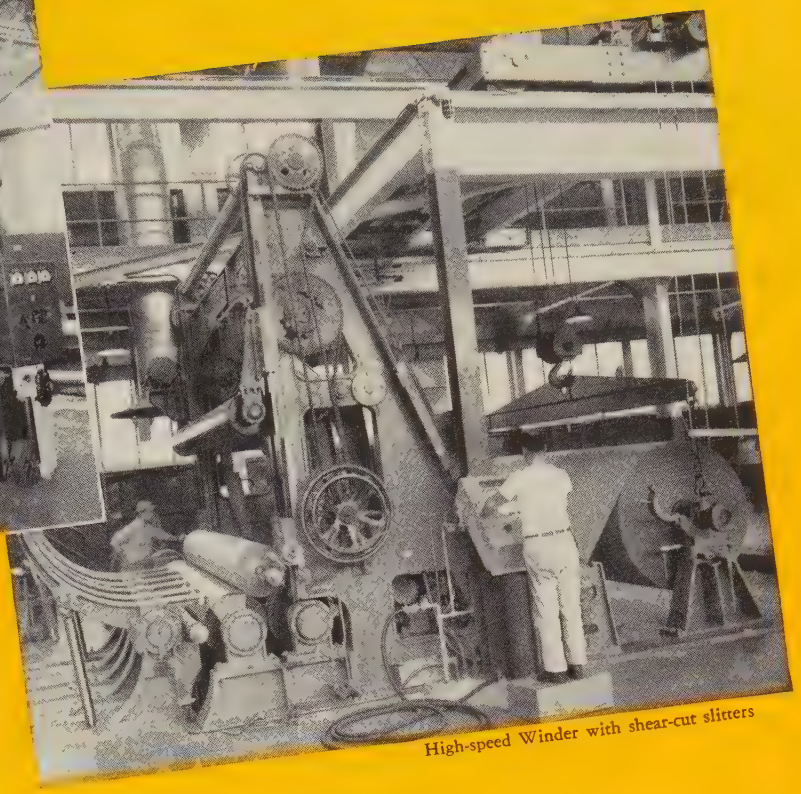
Fig. 18. Allis-Chalmers stream barker

Hydraulic Erosion

	Whole log					*Slabs*
		Ring type				
	Zellerbach hydrobarker (single nozzle)	*Worthington hydrobarker*	*Hensel ring type hydraulic barker*	*Allis-Chalmers stream-barker*	*Bellingham type*	*Hydraulic slab barker*
Manufacturer	Canadian Sumner Iron Works Ltd., Vancouver, B. C.	Worthington Pump & Machinery Co., Seattle, Wash.	Hensel Engineering Co., Ltd., Seattle, Wash., and Vancouver, B. C.	Canadian Allis-Chalmers Ltd., Lachine, P. Q.	Canadian Sumner Iron Works Ltd., Vancouver, B. C. (Cdn. Mfgr.)	Canadian Allis-Chalmers Ltd., Lachine, P. Q., and Canadian Sumner Iron Works Ltd., Vancouver, B. C.
Principle of operation	Logs lifted and centred by two arms which operate like ice tongs. Two lathe "chucks" travel horizontally and grip each end of the log. The arms drop out of sight and the log starts rotating. Above the log there is provided the nozzle carriage and the moment the log starts revolving the nozzle is lowered into position and goes into action. The nozzle travels the length of the log in less than 30 sec. peeling the log cleanly	Adjustable ring type barker contains three equal ring and nozzle, 120° segment assemblies—36 nozzles in all. Log automatically conveyed through barker. Ring is automatically contracted or expanded to fit log size. Only nozzles necessary for log diameter used. Whole operation controlled automatically	Logs are passed through a rotating ring carrying four nozzles designed to handle about 800 g.p.m. at 1200 p.s.i. The ring rotates at approximately 75 r.p.m. and the log is moved forward on feed rolls and does not rotate	The log rotates on two bed rolls, one cast with flutes, the other with spirals. Such arrangement enables the log to obtain a forward motion as well as a turning one. Three jets directly above the log play on the top surface and erode the bark away	The log is rotated partly on and between two sets of gear wheels turning at right angles to the length of the log. As the log rotates a specially designed nozzle travels along and above the full length of the log, the height of the nozzle varying with the diam. of each log being debarked	The slabs are fed into a steel-enclosed compartment by means of specially designed feed rolls and press rolls while water at 1200 to 1400 p.s.i. passing through one oscillating nozzle (or a battery of nozzles) removes the bark in a matter of seconds
Cost	No information	No information	No information	$29,500 f.o.b. Lachine, Que. (1951)	No information	Canadian Sumner Iron Works (1951) $14,000 excluding feed works, drive, pump, and electric motor
Capacity	30 to 40 sec. per log	180 f.p.m.	Small machine—logs 3 to 10 in. in diam. Large machine—logs 10 to 74 in. in diam. (also intermediate sizes)	Logs up to 8 ft. in length, 4 to 24 in. in diam., 8 to 15 cords per hr.	Logs 4 to 72 in. in diam. and from 8 to 20 in ft. length. Modifications are being contemplated to handle even smaller logs and, for sawmill operation, logs up to 40 ft. long	Slabs 12 in. wide and not less than 2 ft. long are minimum sizes. 5 cords per hr. approximately
Horsepower	1000 hp. plus (pressures of from 600 to 1200 p.s.i. at the rate of 500 g.p.m.	1200 to 1400 p.s.i. at velocities of 400 f.p.s. Two pumps each powered by a 1250-hp. G.E. motor	Ring 50 hp. Water pressure 1200 hp.	480 hp. (approx.)	Pressures from 1100 to 1400 p.s.i. at high velocities	Pump motor—900 hp. (800 U. S. g.p.m.) Conveyor drive—10 hp.
Limiting factors	Initial and operating costs are probably high	Initial and operating costs are probably high	Initial and operating costs are probably high	Initial and operating costs are probably high	Initial and operating costs are probably high	Initial and operating costs are probably high



High-speed Winder with score-cut slitters



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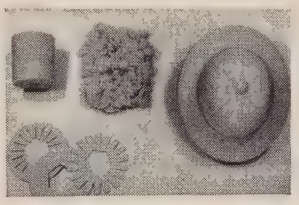

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Fig. 19. Bellingham-type barker

water directed at high pressures onto the bark, thus eroding the bark from the log. Two other machines, the original Weyerhaeuser believed to be a single nozzle hydraulic, and the Simons rotary-head barker which resembles very closely the Hansel ring type, are not included as it has not been possible, up to the time of publication of this report, to obtain the necessary information.

Thermopressure

This method of bark removal, still in the development stage, is a new approach to the problem. The material to be debarked is inserted into a stainless steel cylinder, steam pressure is applied and suddenly released. The bark is reported to be literally "exploded" from the wood.

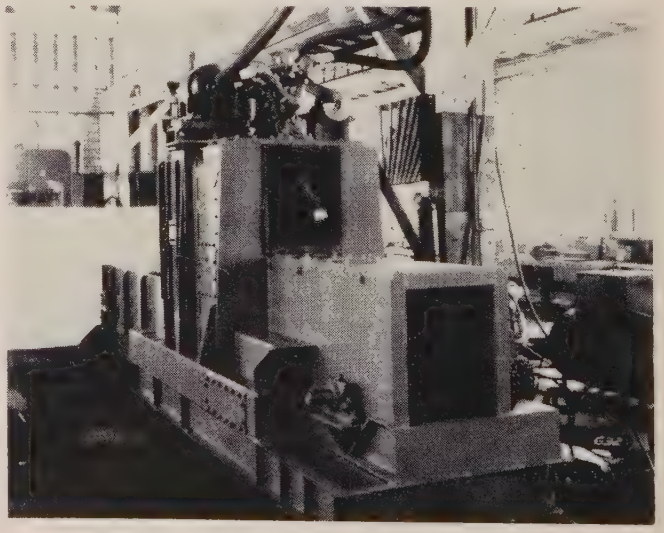

Fig. 20. Sumner hydraulic slab barker

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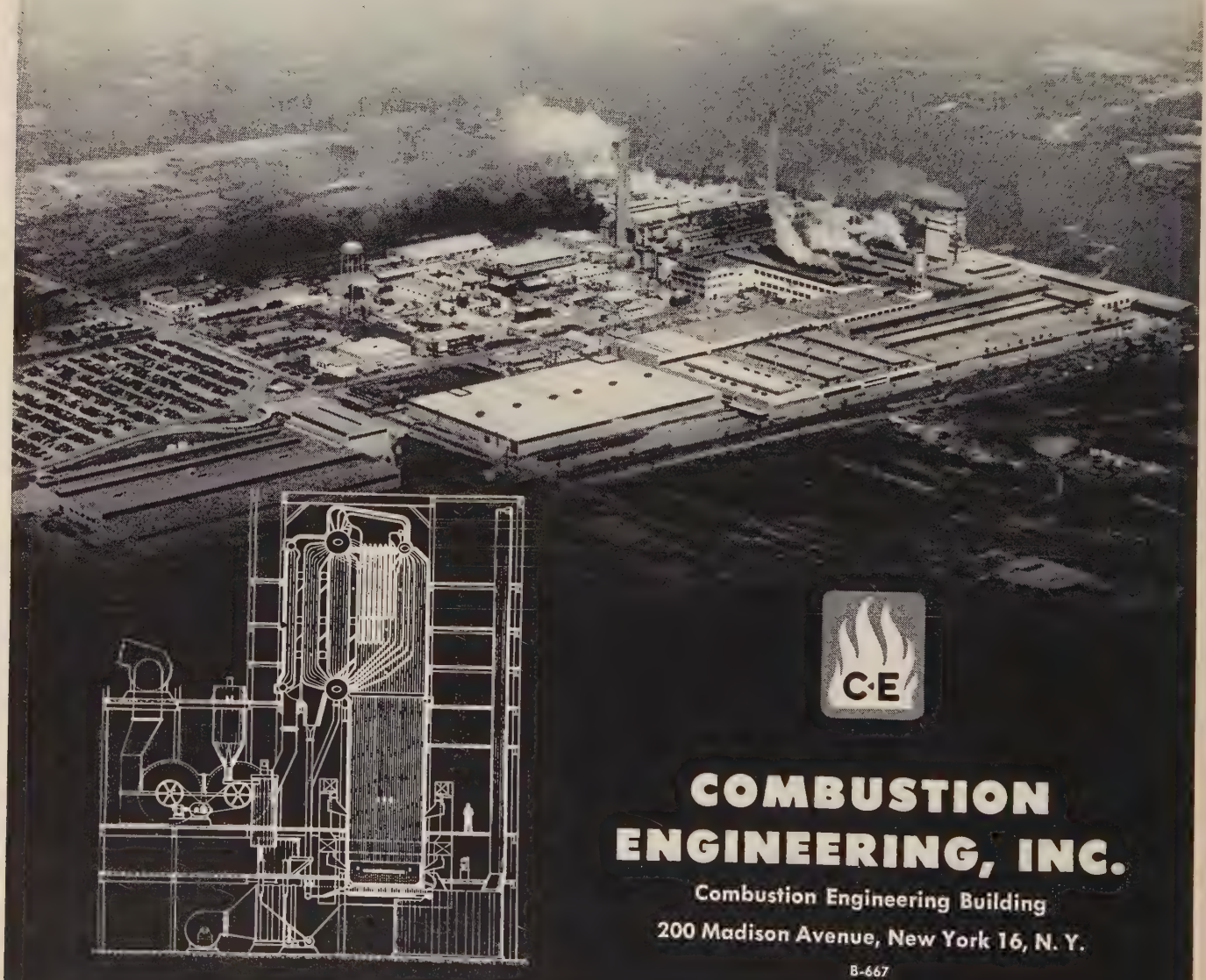

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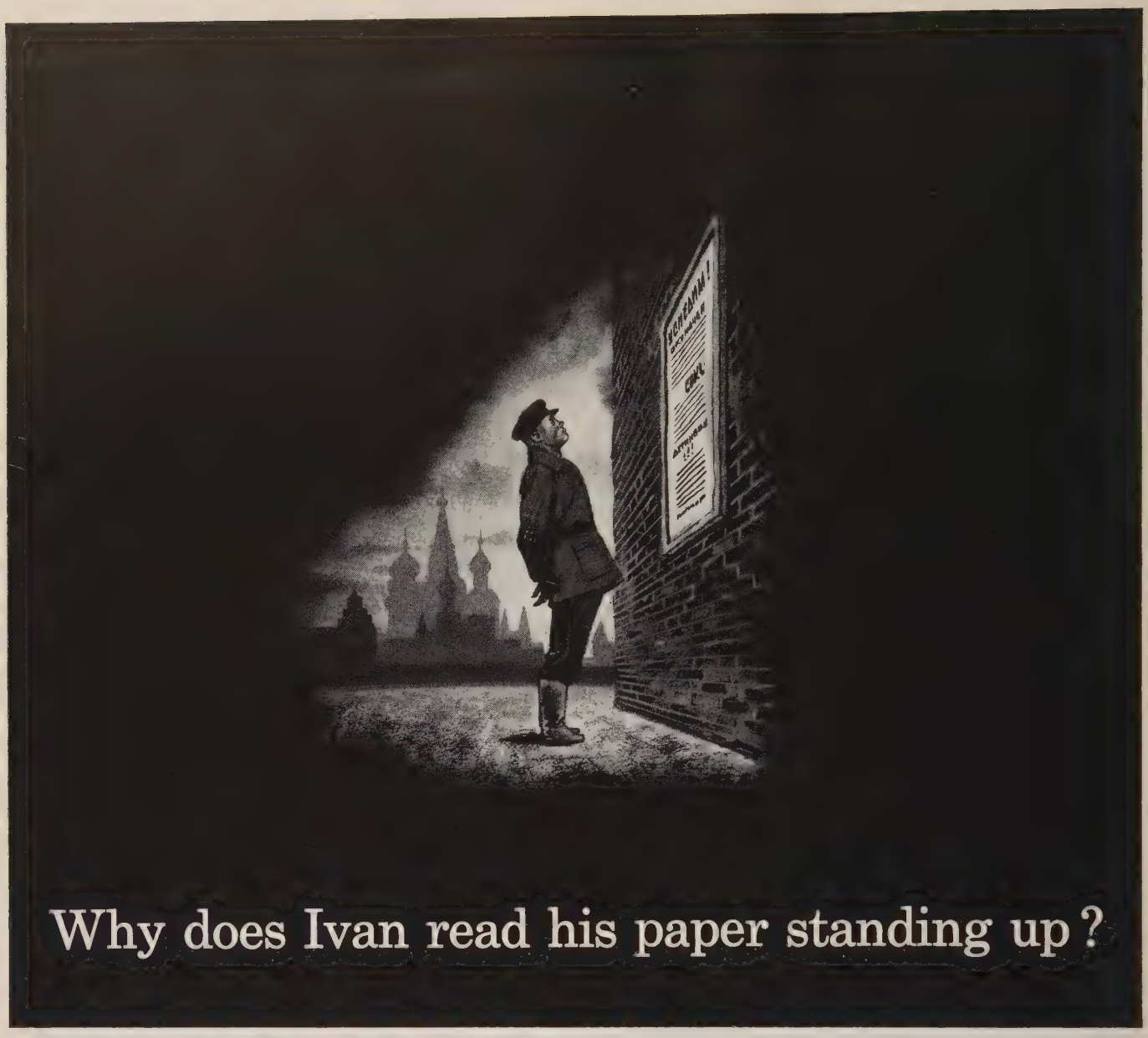

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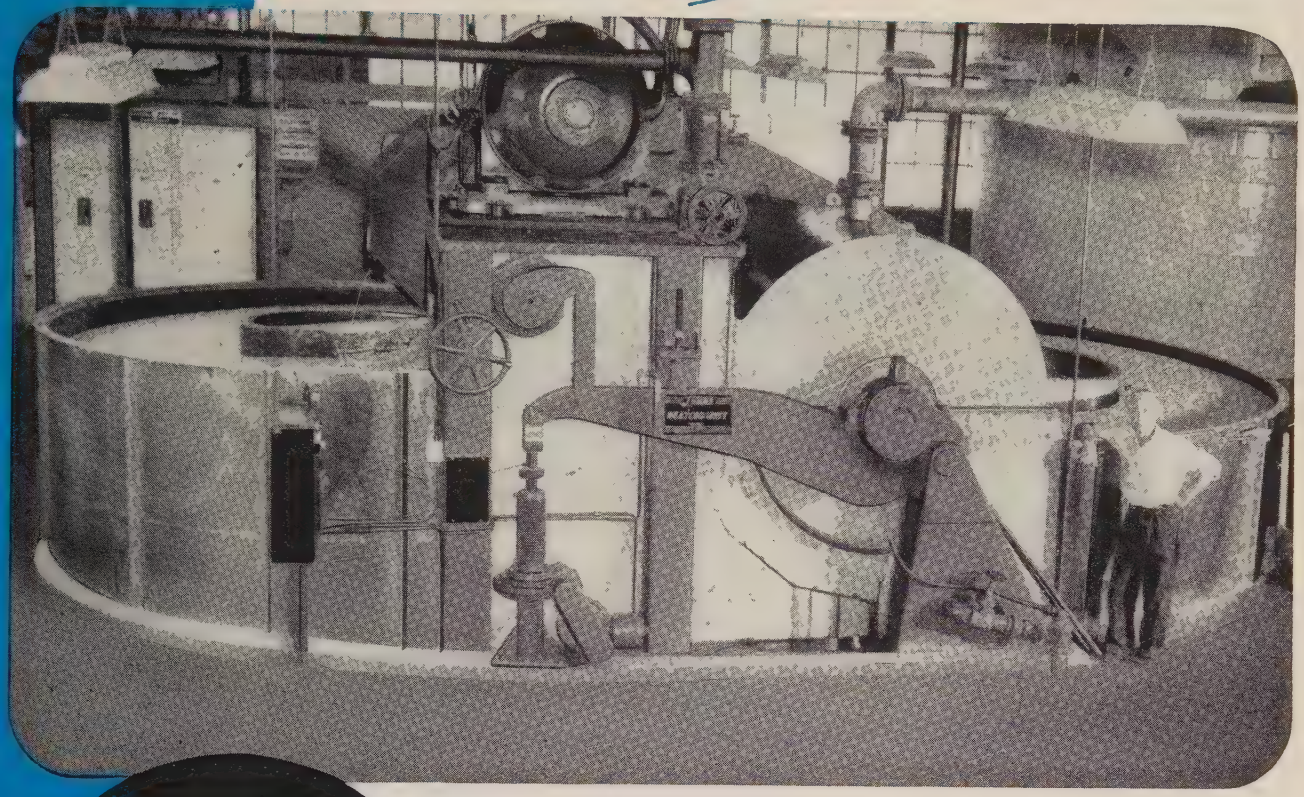

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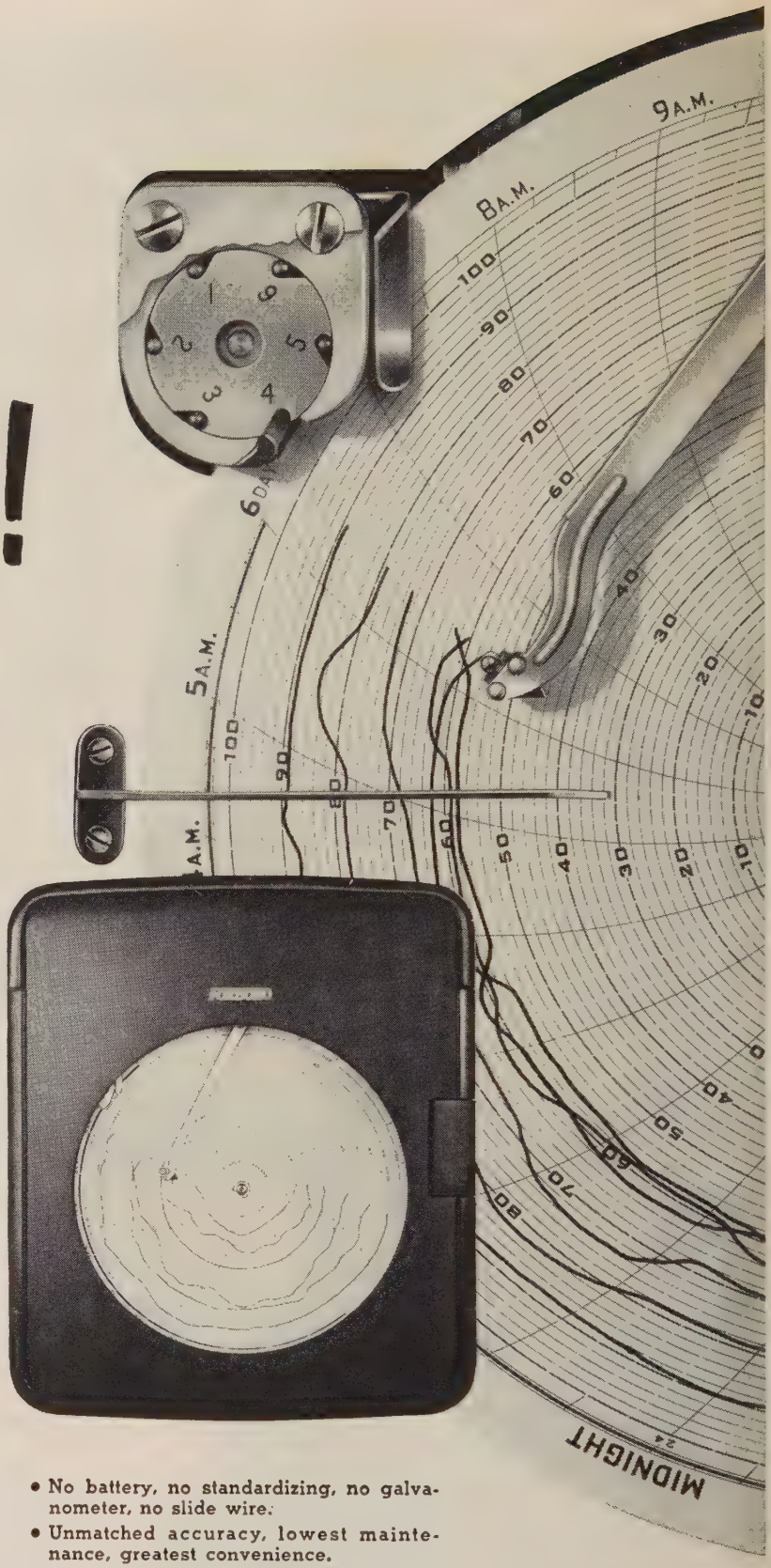

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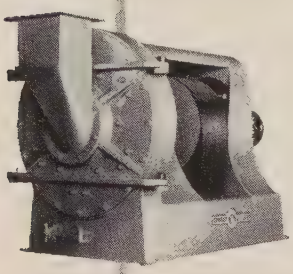

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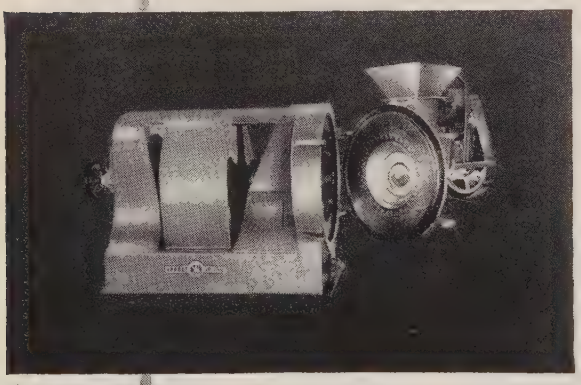

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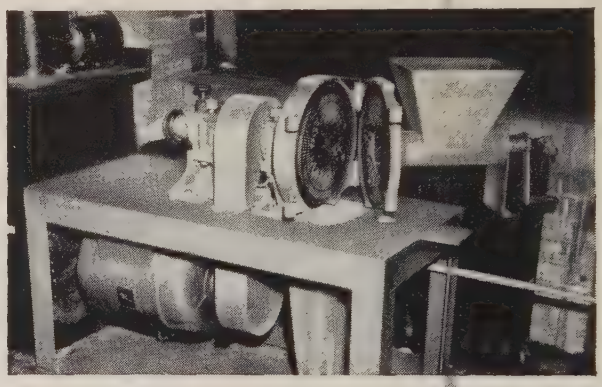

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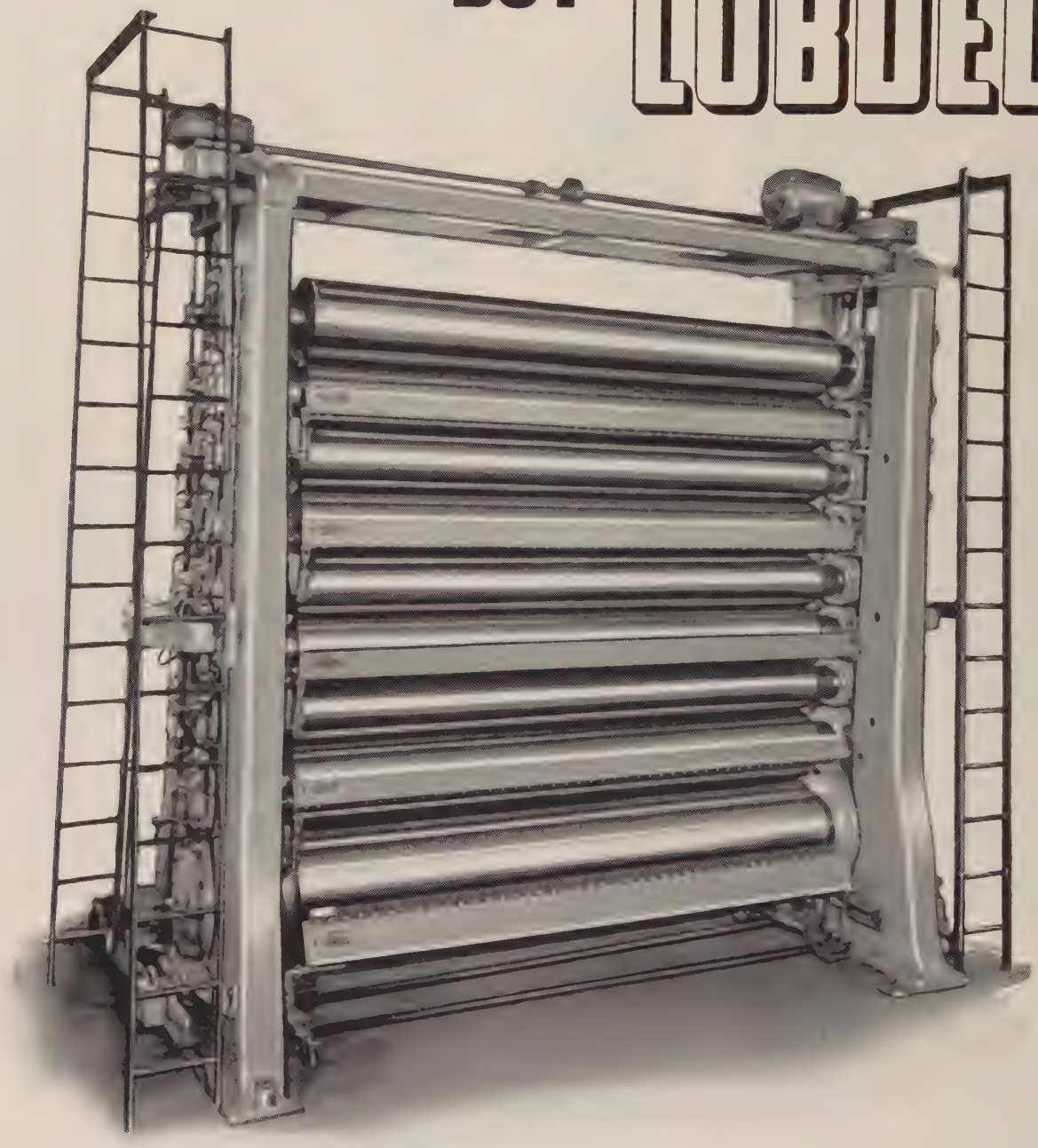

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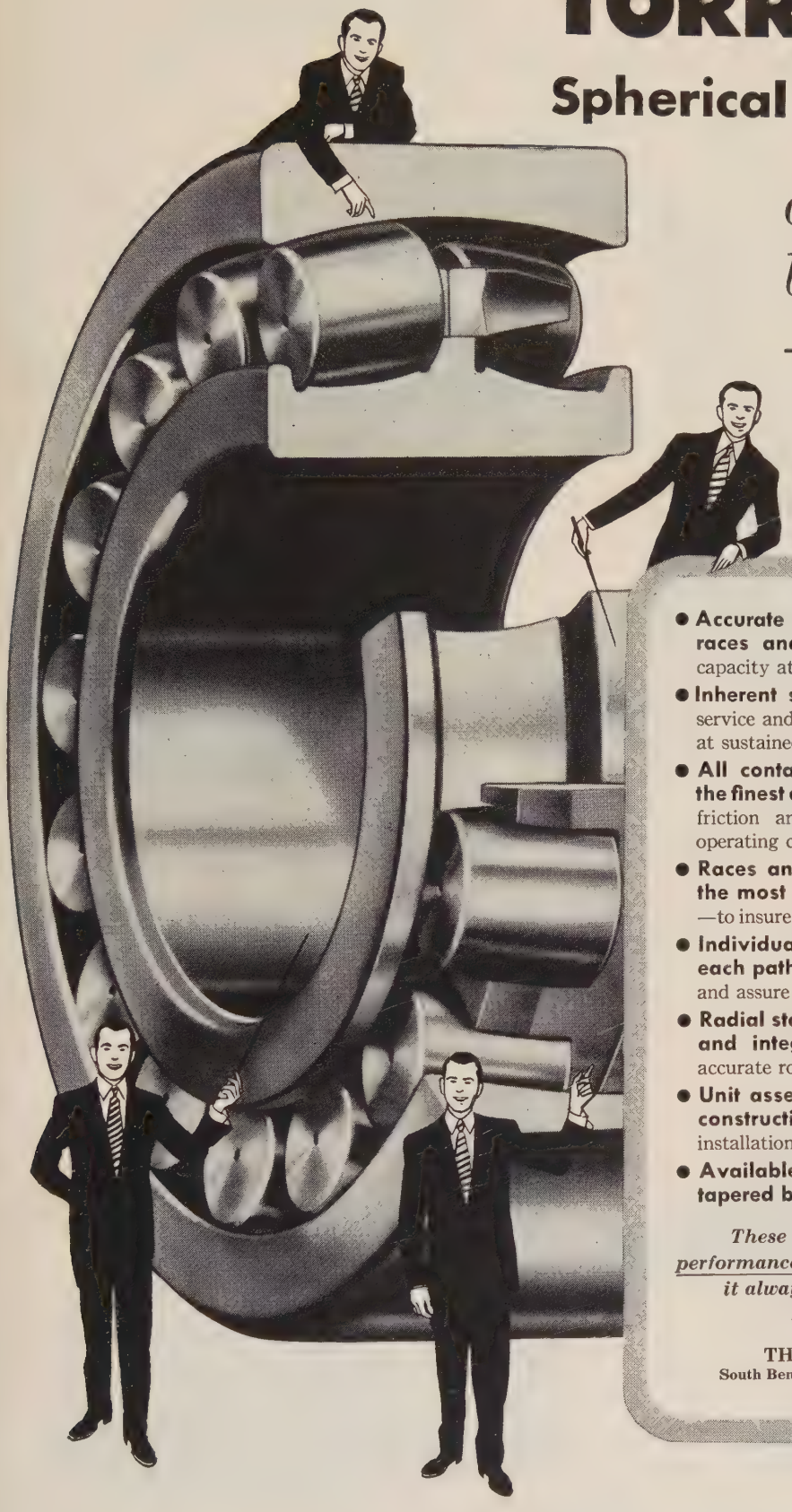

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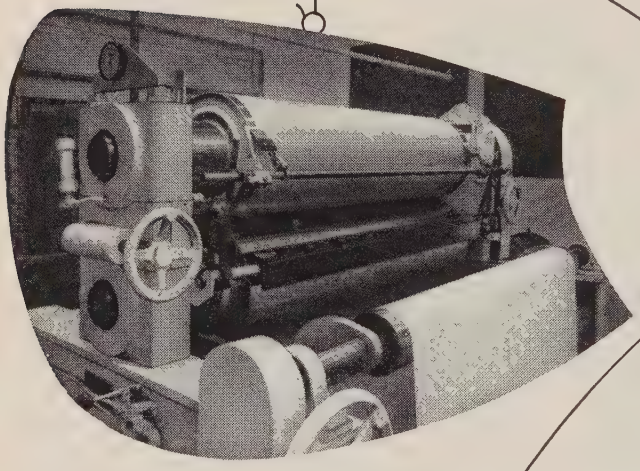

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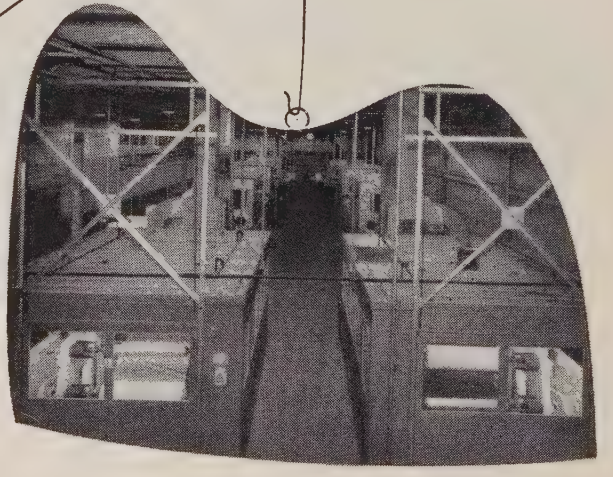

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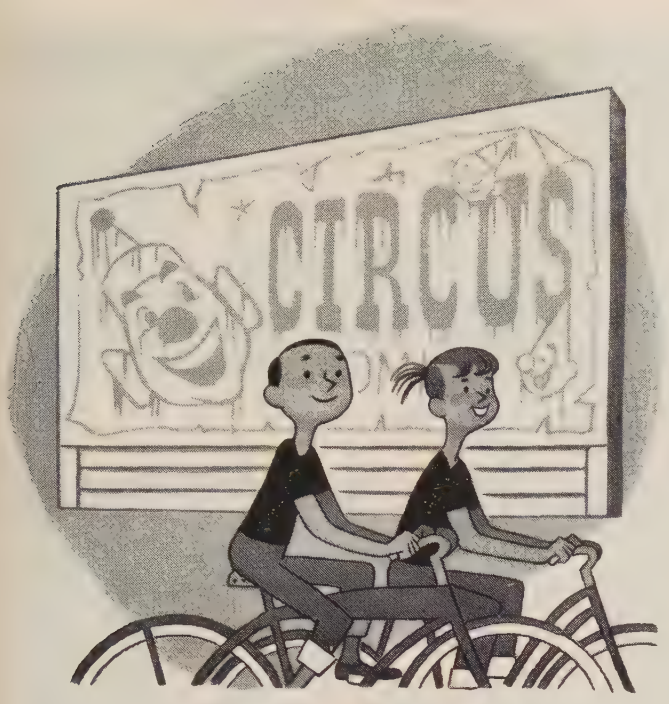

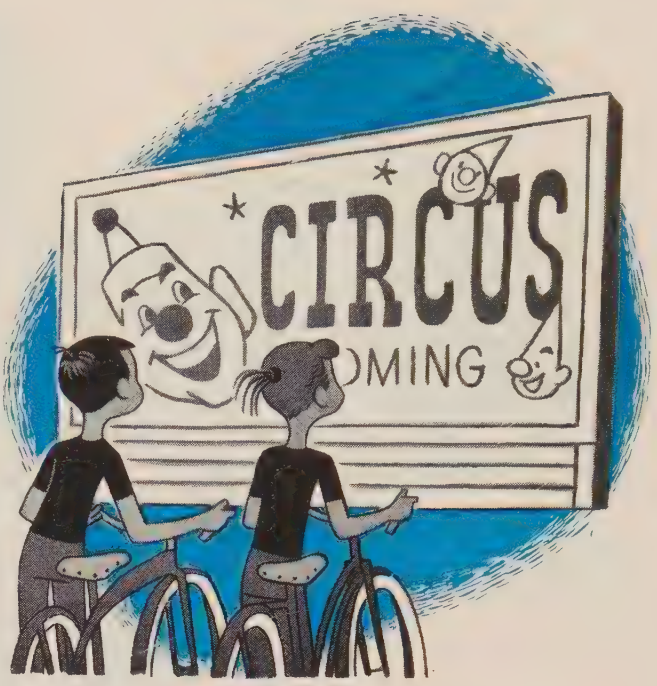

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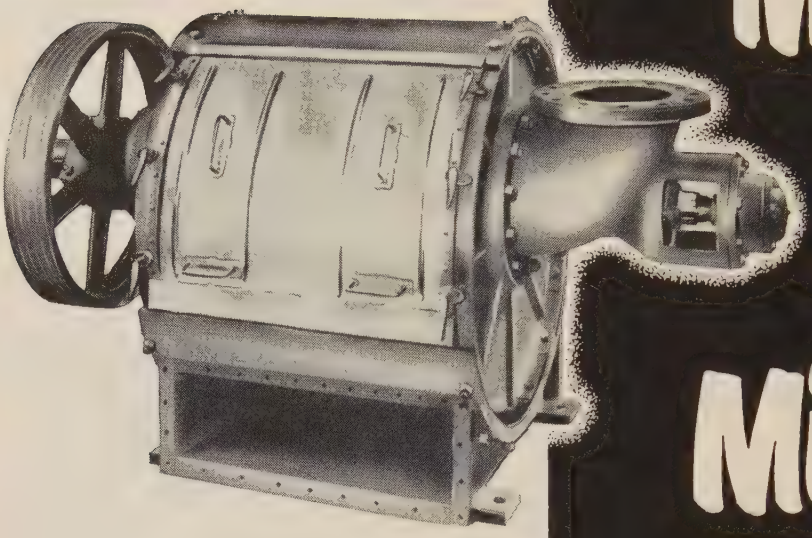

The "Junior" Screen . . . smallest of *three* units producing from 35 to 150 tons per day, respectively.

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Cowan Centrifugal Pulp Screens by
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Added efficiency, greater economy are the watchwords for *Appleton Machine Company's* junior versions of the standard Mark "A" Cowan Centrifugal Pulp Screen, acknowledged as outstanding in its field.

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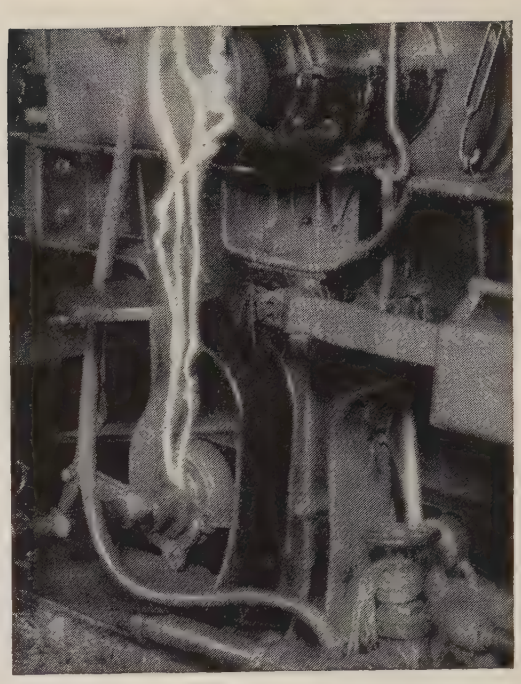

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Many board machines now in operation in U. S. A. are very old. They were designed to run slow. Hamilton Felts are designed to run at speeds that may burn out the bearings of slow-speed machines.

When you increase the speed of your machine, remember that the bottom felt must both transmit the power to operate the wet end cylinders and to deliver your sheet to the dryer rolls as fast as the slitters and winders can take it.

For 94 consecutive years the superintendents of board mills have learned by experience that no felts do their work better, faster or at lower cost than Hamilton Felts.

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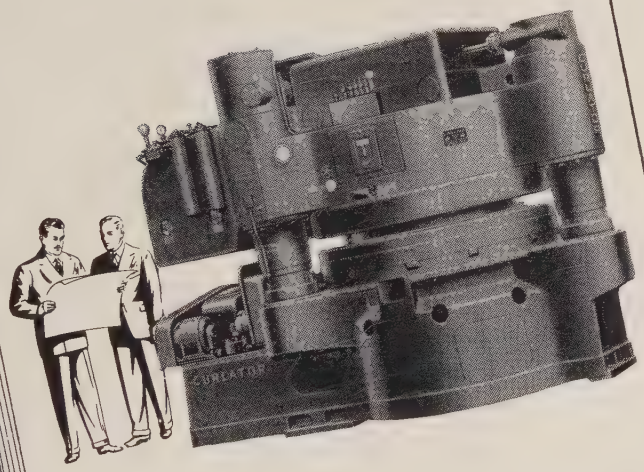

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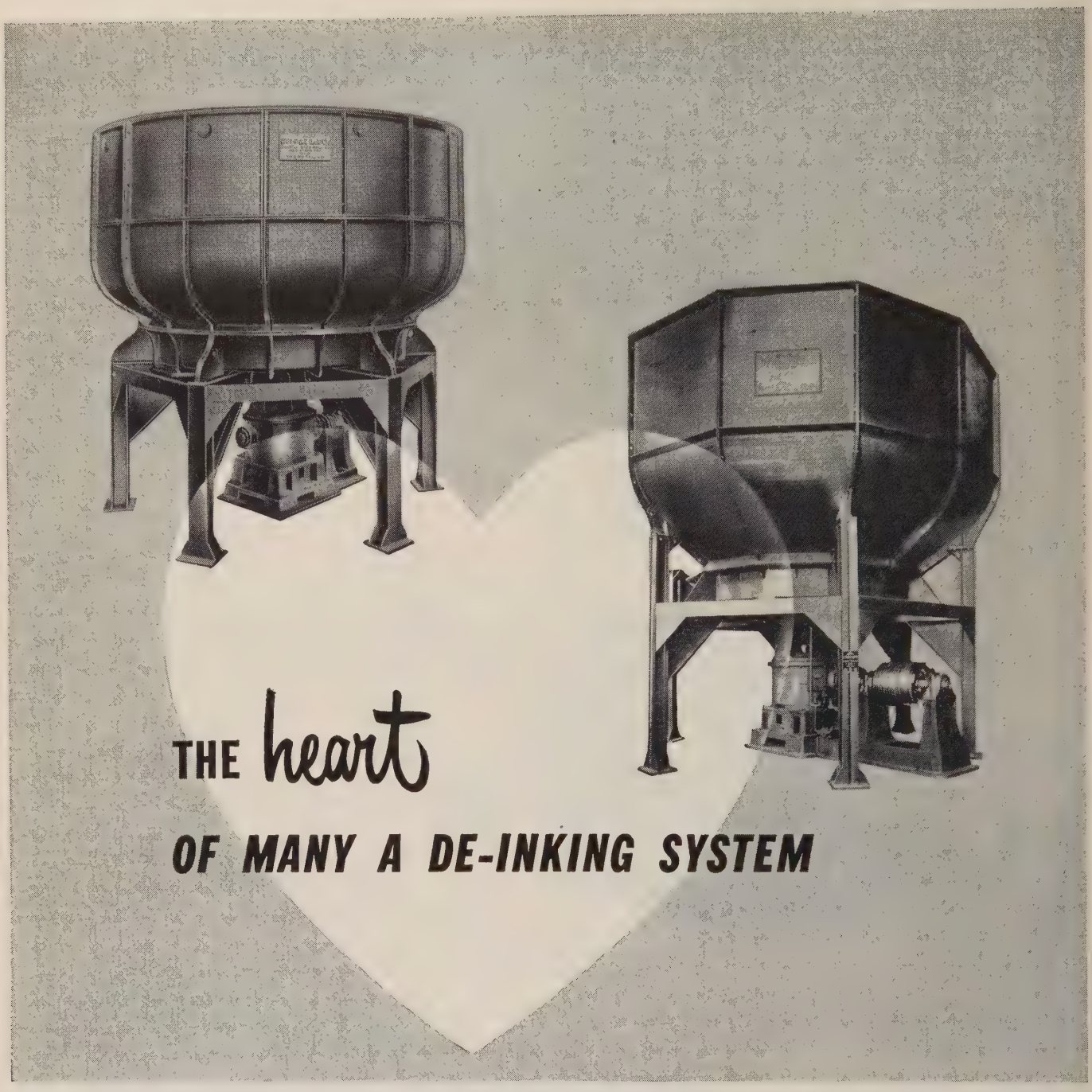

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Bleached Semichemical Pulps from Mixed Eastern Hardwoods for Use in High-Grade Bond Paper

J. N. McGOVERN and F. A. SIMMONDS

Fully bleached neutral sulphite semichemical pulps were produced at the Forest Products Laboratory from a mixture of eastern hardwoods comprising black cherry, black and yellow birch, red and sugar maple, red and white oak, white ash, and beech. A pulping procedure employing preimpregnation of the chips with the cooking liquor and a three-stage bleaching treatment were used. Experimental bond papers made from the bleached semichemical pulp alone and from a blend of approximately equal amounts of the semichemical pulp and a commercial bleached spruce sulphite pulp compared favorably in strength and other properties, except for a slightly lower opacity, with a commercial no. 1 grade of bond paper made from the spruce pulp. It is concluded that 25% or more of bleached semichemical pulp from a broad eastern hardwood mixture can be readily used in no. 1 bond paper if the semichemical pulp is practically free of unbleached particles. A centrifugal separation treatment of the unbleached pulp effectively removed wood dirt and the short, chunky type of shive that is difficultly bleached or resolved by practicable means. Neither the exclusion of oaks and ash from the chip mixture nor crushing of the raw chips between rolls before pulping resulted in reduction of the shive content of the pulps. The yield of bleachable neutral sulphite semichemical pulp from the hardwood mixture was 70%. Pulping characteristics and pulp strength were improved slightly by excluding the oaks and ash from the mixture, although pulp-sheet density was increased. The optimum freeness for fiberizing with respect to shive condition and bleach requirement of the unbleached pulp was 675 to 700 ml. (Schopper-Riegler scale). Bleached semichemical pulp was obtained in about 55% yield, based on the wood. Its strength compared favorably with that of the commercial softwood sulphite pulp, except for a relatively low folding endurance.

Increased cost and decreasing general availability of softwoods favored for pulping demand a supplemental supply of raw material. The hardwoods are promising for meeting this demand, but there are certain limitations in the application of the established sulphate and sulphite processes to hardwoods in specific situations. Attention has therefore turned to the newer semichemical process pioneered by the Forest Products Laboratory. The high yield and good strength characteristics of fully bleached neutral sulphite semichemical pulps made from hardwoods are well known, and their use in all grades of fine papers now depends on the development of procedures to produce clean pulps and on adaptation of semichemical pulp to these grades of paper.

The production of bleached semichemical pulps from a mixture of eastern hardwoods for use in high-grade bond paper was recently investigated at the Laboratory. The scope of the investigation included: (1) production of semichemical pulps from mixtures of six and nine eastern hardwoods in naturally growing proportions using chips as normally prepared and chips that had been crushed between steel rolls; (2) preparation of pulps within a range of freeness values; (3) application of centrifugal separation for removing wood dirt and shives from unbleached pulp; (4) multistage bleaching of the various pulps; and (5) papermaking trials to produce bond paper.

J. N. McGovern, Chemical Engineer, and F. A. Simmonds, Chemist, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, maintained at Madison, Wis., in cooperation with the University of Wisconsin.

PREPARATION OF PULPS

Preparation of Chip Mixtures

The chip mixtures for the digestions of the nine species together had the following composition by weight: 30% of black cherry, 10% of combined black and yellow birch, and 10% each of red maple, sugar maple, beech, red oak, white oak, and white ash. The chip mixtures for the digestions of the six species comprised: 40% of black cherry, 15% of combined black and yellow birch, and 15% each of red maple, sugar maple, and beech.

Experiments were made with normally prepared chips and with chips that had been crushed between the steel rolls of a batch mixing machine with the rolls set about 0.040 in. apart. Both mixtures above were used as normal and crushed chips. The purpose of crushing the chips was to improve the impregnation of the cooking liquor into the chips and thus give more uniform pulping. The crushed chips were not pulped until several weeks after crushing.

The moisture content of the normal and crushed chips was in the range of 25 to 38%, except in two instances in which it was 15%.

Semichemical Pulping

The digestions were made in a digester with a 14-cu. ft. capacity and a stainless steel lining.

Presteaming and impregnation stages were used in the digestion procedure in order to obtain as uniform pulping as possible. This procedure was as follows: (1) the chips were steamed at atmospheric pressure for 30 min.; (2) cooking liquor was added in the amount of 50 gal. per 100 lb. of wood and the digester heated indirectly by means of a steam jacket on the digester to 120°C. in 0.4 hr. and held at this temperature for 1.0 hr.; (3) most of the free liquor was blown from the digester, the residual amount being controlled so as to give the desired amount of cooking chemical; (4) the digester was heated to 170°C. with direct steam in 0.25 hr. and held at this temperature with indirect steam until the concentration of sodium sulphite in the cook-

Table I. Pulping Conditions and Yields for Semichemical Digestions of Mixtures of Eastern Hardwoods

Impregnation[a]					Cooking[b]			
Liquor charged			Chemicals retained					
Na_2SO_3, gm./l.	$NaHCO_3$, gm./l.	volume gal./100 lb. wood	Na_2SO_3 lb./100 lb. wood	$NaHCO_3$ lb./100 lb. wood	Time at 170°C. hr.	Na_2SO_3 in spent liquor gm./l.	Yield, %	Lignin content of pulp, %
				Nine-Species Mixture[c]				
146.3	48.4	48.8	18.3	9.3	3.25	20.4	70.0	10.7
				Six-Species Mixture[d]				
151.0	57.9	47.6	18.8	10.3	3.25	18.7	68.6	10.2
				Normal Chips				
150.1	50.3	48.3	19.0	9.7	3.25	19.9	70.0	10.7
				Crushed Chips				
146.6	46.7	48.6	18.8	9.2	3.25	20.2	69.4	10.5

[a] Other conditions: Presteaming at atmospheric pressure for 0.5 hr.; heating with indirect steam for 0.5 hr. to 120°C. and holding 1 hr. at this temperature.
[b] Other conditions: Heating for 0.25 hr. from 120 to 170°C. using direct steam; indirect steam used at 170°C.; pressure of 148 p.s.i. during cooking (digester not relieved).
[c] Black cherry, yellow and black birch, red and white oak, red and sugar maple, white ash, and beech.
[d] Black cherry, yellow and black birch, red and sugar maple, and beech.

ing liquor reached about 10 grams per liter. The digester was rotated throughout the impregnation and cooking stages to obtain uniform conditions. The average pulping conditions for chip mixtures are given in Table I, together with data on the yield and lignin content of the pulps.

Fiberizing Conditions

The softened and partially pulped chips from the digester were fiberized in a double-disk attrition mill of commercial size. The fiberizing conditions were chosen to give the optimum balance between shive condition and freeness, except for one series of runs in which the freeness of the pulps ranged from high to low.

Bleaching

The bleaching treatment comprised a sequence of chlorination, extraction with sodium hydroxide, and oxidation with calcium hypochlorite. After each stage of treatment the pulp was washed thoroughly with water. Both small and large-scale bleaching equipment were used. A brightness of 85% was desired for the bleached pulps.

PULP AND PAPER TESTING

The strength tests of the pulps and papers and the chemical tests on the pulps were made according to TAPPI Standards. The freeness of the pulps was determined by the Schopper-Riegler test method. Folding endurance was determined with the M.I.T. tester.

SEMICHEMICAL PULPING AND PULPS

Pulping of Nine-Species Mixture

The mixture of the nine hardwoods responded normally to the neutral sulphite semichemical process as judged by the requirements of cooking chemical and time and by the yield and the lignin content of the pulp (Table I). The sodium sulphite requirement of about 19% of the weight of the wood (480 lb. per ton of air-dry pulp) was intermediate in the range of 14 to 22% found in tests at the Forest Products Laboratory on a large number of American hardwoods in making pulps with lignin contents of 10 to 12%. The yield of 70% of this pulp was also intermediate in the range of 65 to 75% for the pulps in the previous tests.

Although the experimental pulping procedure included a separate impregnation stage to insure the greatest uniformity of pulping, a subsequent test on the same wood mixture indicated that uniformly pulped chips could also be made in a conventional one-stage

Table II. Strength Properties of Unbleached Semichemical Pulps Made from Mixtures of Eastern Hardwoods

Pulp condition	Freeness, ml.	Strength tests[a]				
		Bursting strength, pt./lb.	Tearing resistance, gm./lb.	Folding endurance, double folds	Tensile strength, m.	Density, gm./cc.
			Nine-Species Mixture[b]			
Unbeaten	790	0.56	1.16	33	5500	0.60
Beaten	650	0.70	1.11	84	6500	0.66
			Six-Species Mixture[c]			
Unbeaten	730	0.45	1.20	30	5450	0.60
Beaten	650	0.72	1.09	125	6700	0.65
			Normal Chips			
Unbeaten	785	0.50	1.20	16	5100	0.58
Beaten	650	0.71	1.09	100	6800	0.67
			Crushed Chips			
Unbeaten	760	0.60	1.18	50	5750	0.62
Beaten	650	0.69	1.12	93	6300	0.66

[a] Based on a ream of 500 sheets, 25 by 40 in.
[b] Black cherry, yellow and black birch, red and white oak, red and sugar maple, white ash, and beech.
[c] Black cherry, yellow and black birch, red and sugar maple, and beech.

Table III. Density and Lignin Content of Eastern Hardwoods

Species	Density,[a] lb./cu. ft.[c]	Lignin content,[b] %
Black cherry (*Prunus serotina*)	30.4	21.0
Sugar maple (*Acer saccharophorum*)	35.4	22.3
Red maple (*A. rubrum*)	30.7	21.8
Yellow birch (*Betula allegheniensis*)	35.9	22.4
Black birch (*B. lenta*)		
Beech (*Fagus grandifolia*)	34.9	21.6
White ash (*Fraxinus americana*)	34.1	26.4
White oak (*Quercus alba*)	37.5	26.8
Red oak (*Q. borealis*)	35.2	..
Mixture of foregoing species[d]	33.5	..

[a] Average values from tests at Forest Products Laboratory.
[b] Average values from tests at Forest Products Laboratory and literature.
[c] Based on weight when oven dry and volume when green.
[d] Thirty per cent of black cherry, 10% of combined yellow and black birch, and 10% each of sugar maple, red maple, beech, ash, white oak, and red oak.

operation with a temperature-rise period of 2.5 hr. to the cooking temperature of 170°C. This test also showed that the sodium bicarbonate requirement for buffering the cooking liquor was about 5% instead of the 9% used in the experiments employing the separate impregnation stage. Thus, the approximate amounts of basic chemicals needed to produce 1 ton of pulp (air-dry basis) of the grade described in the preceding paragraph are: 120 lb. of sulphur and 500 lb. of soda ash.

The energy required to fiberize the semichemically cooked chips to a freeness of about 780 ml. (Schopper-Riegler) was 16 hp.-days per ton of air-dry pulp.

Unbleached Pulp from Nine-Species Mixture

The unbleached pulp from the nine-species mixture had good strength properties for an unbleached semichemical pulp (Table II). In comparison with aspen semichemical pulp, which is of known high quality, the mixture of eastern hardwoods gave a pulp with a slightly lower bursting strength and a somewhat higher tearing resistance. It is estimated that the semichemical pulp from the mixture had about 70% of the bursting strength and 90% of the tearing resistance of unbleached spruce sulphite pulp of good quality.

Pulping of Six-Species Mixture

The individual hardwoods ranged rather widely in their density and lignin content (Table III). The range of density was from 30.4 to 37.5 lb. per cu. ft., and of lignin content from 21.0 to 26.8% the extremes being black cherry and white oak, respectively, for both density and lignin content. A test was made to determine how the exclusion of the denser woods with high lignin contents, namely, the oaks and ash, would affect the pulping characteristics of the remaining mixture and the quality of the pulp. The six-species mixture absorbed slightly more chemicals, as would be expected from its lower average density, and gave a pulp in a slightly lower yield and with a lower lignin content than the nine-species mixture (Table I).

Unbleached Pulp from Six-Species Mixture

The strength properties of the unbleached pulp from the six-species mixture were of the same order as those of the pulp from the nine-wood mixture and the small differences in favor of the former could be attributed to its lower lignin content in comparison with the pulp from the nine-species mixture (Table II).

Comparison of Normal and Crushed Chips

The normal and crushed chips showed closely the same pulping characteristics (Table I). The unbleached pulps from the normal and crushed chips also had the same strength properties (Table II).

It is possible that differences would have been found if the chips had been used immediately after being crushed, rather than several weeks later, or if the chips had been compressed in the presence of the cooking liquor.

Table IV. Bleaching Data for Semichemical Pulps Made from Mixtures of Eastern Hardwoods

Chemicals[a]		Bleaching data			Bleached pulp	
Kind by stage	Amount, %	Consistency, %	Temperature, °C.	pH Value	Time, min.	Yield, based on wood, %	Brightness, %
			Nine-Species Mixture[b]				
Cl_2	11.0	2.5	25	1.5– 2.0	90	...	..
NaOH	2.0	10.0	71	11.6–11.1	60	..	..
$Ca(OCl)_2$	5.0	10.0	37	9.7– 9.1	240	57.2	83.9
			Six-Species Mixture[c]				
Cl_2	10.0	2.5	25	1.5– 2.0	90	..	..
NaOH	2.5	10.0	69	11.3–10.9	60	..	..
$Ca(OCl)_2$	4.0	10.0	35	8.9– 8.6	270	55.3	85.1
			Normal Chips				
Cl_2	11.0	2.5	25	1.5– 2.0	90	..	.
NaOH	2.0	10.0	71	11.6–11.3	60	..	..
$Ca(OCl)_2$	3.5	10.0	35	9.1– 9.0	240	57.1	85.2
			Crushed Chips				
Cl_2	10.5	2.5	25	1.5– 2.0	90	..	
NaOH	2.0	10.0	71	11.6–11.4	60	..	..
$Ca(OCl)_2$	3.5	10.0	35	9.3– 8.8	240	58.0	84.5
			Unbleached Cleaned Pulp for Papermaking Experiments[d]				
Cl_2	11.5	3.5	25	1.5– 2.0	70	.	..
NaOH	2.5	10.5	70	11.0–10.6	60	..	.
$Ca(OCl)_2$	2.0	11.8	38	9.3– 9.2	270	55.0	83.9

[a] Percentage values are based on weight of moisture-free unbleached pulp; those for calcium hypochlorite refer to available chlorine.
[b] Black cherry, yellow and black birch, red and white oak, red and sugar maple, white ash, and beech.
[c] Black cherry, yellow and black birch, red and sugar maple, and beech.
[d] Pulp cleaned in a centrifugal separator.

BLEACHING AND BLEACHED PULPS

Bleaching

The unbleached pulps from the hardwood mixtures responded satisfactorily to conventional three-stage bleaching. With the application of 13 to 16% of total chlorine, the brightness of the bleached pulps ranged from 83 to 86% (Table IV). The ratio of the total amount of chlorine to the lignin content of the corresponding pulps was in the range of 1.3 to 1.45, which is typical for hardwood semichemical pulps. The unbleached pulps varied in shive content, although all were appreciably high in this respect.

In bleaching the pulps not subjected to centrifugal cleaning, it was sometimes necessary to apply as much as 40% of the total chlorine in the form of calcium hypochlorite in the last stage in order to effect a reasonably satisfactory bleaching of the shives and dirt. This partition of chlorine is harmful to the strength of pulp. A generally satisfactory partition is 80% to the chlorination stage and 20% to the hypochlorite stage. The shives in the pulps in these experiments were fairly well bleached, but partially bleached material appearing as flakes was perceptible. The more advantageous partition is possible if the shives are removed before bleaching.

The chemical requirements for producing 1 ton of bleached pulp (air-dry) were: sulphur, 155 lb.; soda ash, 640 lb.; chlorine, 350 lb.; and sodium hydroxide, 45 lb.

The bleached pulps from the nine and six-species mixtures showed no difference in shive and dirt content. The pulp from the six species, however, responded somewhat better to bleaching than the other with respect to brightness and chlorine requirement (Table IV). This behavior was in accord with the difference previously noted in the lignin contents of the unbleached pulps (Table I).

The pulps from the normal and crushed chips showed practically the same response to bleaching (Table IV), and the bleached pulps were similar in content of shives and dirt.

Strength Properties of Bleached Pulps

An appreciable improvement in pulp strength was realized as a result of bleaching the semichemical pulps (Tables II and V), as is typical of semichemical pulps. The improvements in the average values for comparable pulps were 35% in bursting strength, 10% in tensile strength (breaking length), and 150% in folding endurance. Tearing resistance was unchanged by bleaching.

The bleached pulps made from the six-species mixture were slightly stronger, except in tearing resistance, than those made from the nine species (Table V). The pulps made with the oaks and ash excluded were also more dense than pulps made with these species present. The oaks in particular in many other tests have given more bulky bleached semichemical pulps with lower bursting strength and higher tearing strength than other woods. These differences in pulp characteristics are in accord with the influence of differences in cell-wall thickness as brought out in a recent classification of these hardwoods according to the Mülsteph system (*1*).

The bleached pulps from the normal and crushed chips had the same strength properties within the limits of experimental error (Table V).

The strength properties of the bleached hardwood semichemical pulps were compared with those of a bleached softwood sulphite pulp that was considered to be a high-quality pulp suitable for bond-grade paper. The hardwood pulps closely approached the softwood pulp, in bursting strength, had a somewhat higher tearing resistance, but were somewhat lower in tensile strength and appreciably lower in folding endurance. Their strength properties were sufficiently high, however, to warrant serious consideration of the hardwood semichemical pulps as a substitute or supplement for the softwood sulphite pulp in bond-grade paper.

Table V. Strength Properties of Bleached Semichemical Pulps Made from Mixed Eastern Hardwoods and Commercial Bleached Spruce Sulphite Pulp

Pulp condition	*Freeness, ml.*	*Strength tests*[a] *Bursting strength, pt./lb.*	*Tearing resistance, gm./lb.*	*Folding endurance, double folds*	*Tensile strength, m.*	*Density, g./cc.*
			Nine-Species Mixture[b]			
Unbeaten	710	0.83	1.18	95	6,450	0.72
Beaten	650	0.93	1.13	222	7,000	0.74
			Six-Species Mixture[c]			
Unbeaten	725	0.90	1.14	115	7,200	0.75
Beaten	650	1.02	1.00	350	8,600	0.82
			Normal Chips			
Unbeaten	720	0.84	1.17	101	6,650	0.72
Beaten	650	0.95	1.06	242	7,500	0.76
			Crushed Chips			
Unbeaten	720	0.93	1.11	116	7,400	0.77
Beaten	650	0.97	1.11	293	7,500	0.76
			Commercial Softwood Sulphite Pulp (Bond Grade)			
Slightly beaten	750	0.96	0.92	596	8,500	..
Beaten	650	1.02	0.88	950	10,000	..

[a] Ream of 500 sheets, 25 by 40 in.
[b] Black cherry, yellow and black birch, red and white oak, red and sugar maple, white ash, and beech.
[c] Black cherry, yellow and black birch, red and sugar maple, and beech.

Table VI. Influence of the Degree of Fiberization on Brightness and Bleach Requirement in the Semichemical Pulping of a Mixture of Nine Eastern Hardwoods[a]

Unbleached pulp			Bleached pulp	
Freeness, ml.	*Fiberizing energy hp.-days/ air-dry ton*	*Brightness, %*	*Total chlorine applied, %*	*Brightness, %*
		Series I		
800	15.8	41.9	14.5	85.2
670	21.2	40.6	14.5	85.2
400	32.0	36.6	15.0	83.5
		Series II		
790	16.3	42.2	14.0	84.2
610	..	41.1	14.0	84.5
395	..	37.9	15.3	83.4

[a] Black cherry, black and yellow birch, red and white oak, red and sugar maple, white ash, and beech.

EFFECT OF DEGREE OF FIBERIZATION ON CERTAIN PULP PROPERTIES

The degree of fiberization of the partly cooked chips affected the shive condition of the pulp, as might be expected, and it also appeared to affect the response of the pulp to bleaching (Table VI). The freeness of the pulp was taken as the measure of the degree of fiberization. A decrease in freeness from a high value near 800 ml. to an intermediate freeness of approximately 650 ml. caused a large reduction in the number of shives, but a further decrease to a low value near 400 ml. did not result in a further decrease in the number of shives. The brightness of the unbleached semichemical pulp was decreased by increased fiberizing action in accord with the usual effect of mechanical processing on the brightness of pulps. There was an indication that the lowest-freeness pulp did not respond so well to bleaching as the two pulps of higher freeness. Possibly this effect is related to the optical properties of the test sheets rather than to contamination of the pulp. Milling to the intermediate freeness thus gave the optimum effect with respect to shive content and bleachability.

The unit energy consumption for fiberizing the partly cooked chips increased with decreasing freeness (Table VI). For fiberizing to an intermediate freeness the average value was about 20 hp.-days per ton. This value is an approximation because of the relatively small amount of material that was passed through the commercial-sized attrition mill. An appreciably lower power consumption would be expected in continuous mill operation.

CLEANING PULPS MECHANICALLY

The short, chunky type of shive common to semichemical pulp limits its usefulness. Experiments were made with a laboratory model of a centrifugal separator designed to remove this type of shive as well as wood dirt (*2–4*).

In preliminary experiments, unbleached pulp made from the nine-species mixture was put through the separator. A qualitative inspection of handsheets made from the pulp before and after centrifugal separation showed that most of the short, chunky shives and the wood dirt was removed by the separator. The beneficial effect of this cleaning was especially evident upon comparing bleached original and bleached cleaned pulps. A quantity of pulp was therefore cleaned and then bleached in pilot plant equipment for use in the papermaking trials. As a result of the cleaning, it was possible to bring the partition of chlorine down to 15% in the hypochlorite stage (Table IV).

Since the separator was suitable for removing only the short, chunky type of shive, the long, narrow type remained in the pulp after the processing. More recently, a hardwood semichemical pulp was made at the Forest Products Laboratory and processed elsewhere by passage through a combination of two appropriately designed separators in series. The cleaned pulp was essentially free of all shives and dirt; after bleaching its appearance was excellent. Thus, the shives inherent in semichemical pulps no longer seem to be a limitation to the usefulness of these pulps.

EXPERIMENTAL BOND PAPERS

Experimental bond papers were made from bleached semichemical pulps alone and also from a blend of approximately equal amounts of the experimental pulp and a commercial bleached softwood sulphite pulp. Standards used for comparison were a commercial spruce sulphite bond paper of no. 1 grade and an experimental paper made from wet broke taken from a mill run on bond paper. The paper from wet broke had the obvious advantages as a reference standard of reproducing a mill's furnish and its preparation while minimizing the effect of variables of papermaking.

As internal sizing, 1% of rosin was used, and a surface sizing of starch was applied. Clay filler was added in the amount of 7.5%.

The experimental papers containing the bleached semichemical pulps made from the mixtures of hard-

Table VII. Comparison of Strength Properties of Experimental Papers Made from Bleached Hardwood Semichemical Pulp and a Commercial Bond Paper

Bleached pulps used		Test values for papers[a]										
Hardwood[b] semichemical, %	*Commercial spruce sulphite, %*	*Weight,[c] lb.*	*Thickness, mils*	*Density, g./cc.*	*Bursting strength, pt./lb.*	*Tearing resistance, g./lb.*	*Folding endurance, double folds*	*Tensile strength, lb./in. width*	*Size no.*	*Air resistance, sec./100 ml.*	*Opacity, %*	*Ash, %*
					Commercial Bond Paper[d]							
0	0	53.0	3.9	0.76	0.52	1.09	48	23.5	0.91	22	84.7	6.7
					Paper Made from Wet Broke[e]							
0	0	52.5	3.5	0.83	0.46	0.96	62	20.7	1.77	47	85.5	7.0
					Papers Made from Bleached Semichemical Pulps from Eastern Hardwood Mixture							
100	0	51.8	3.7	0.78	0.74	1.03	130	27.5	0.86	14.6	78.9	5.0
44	56	51.8	3.6	0.80	0.61	1.04	147	25.7	2.18	109.1	81.3	5.2

[a] All papers were surface-sized with starch. The semichemical pulp furnishes contained 1% of rosin size, 2% of alum, and 7.5% of clay based on total weight of pulp.
[b] Made from mixture of black cherry, black and yellow birch, red and white oak, red and sugar maple, white ash, and beech. Pulp was cleaned in centrifugal separator before bleaching.
[c] Ream of 500 sheets, 25 by 40 in.
[d] Made from bleached spruce sulphite pulp.
[e] Supplied from a mill run of bond paper.

woods had strength properties equal to or better than those of the papers used for comparison (Table VII). The test values for the air resistance and internal sizing of the papers made with semichemical pulps were unexplainably wide in their variation. Since this variation included the values for the standard papers, however, it is reasonable to expect these characteristics could be brought under control in sustained production.

The semichemical papers were lower in opacity than the commercial paper used as a standard—2% lower on a thickness basis and 7.5% lower on a weight basis. This difference may have been due partly to the lower amount of filler present in the semichemical papers as shown by their lower ash contents in comparison with the standards.

Although the amount and visibility of shives in the semichemical papers made in this investigation were probably too great for the no. 1 grade of bond paper, undoubtedly considerable improvement could be obtained by appropriate application of centrifugal cleaning. It should be possible to use at least 25%, and probably considerably higher percentages, of bleached hardwood semichemical pulp in bond paper of the highest quality.

LITERATURE CITED

1. Haywood, Gerald, *Tappi* 33, No. 8: 370–383 (Aug. 1950).
2. Rastatter, E. L., and Croup, A. H., *Tappi* 35, No. 5: 223–227 (May 1952).
3. Samson, E. W., and Croup, A. H., *U. S. pat.* 2,377,524, June 5, 1945.
4. Tomlinson, II, G. H., and Tuck, N. G. M., *Pulp Paper Mag. Can.* 53, No. 12: 109–114 (Nov. 1952).

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Chemists E. L. Keller and R. M. Kingsbury of the Forest Products Laboratory contributed importantly to the investigation.

Determination of Pentosans in Highly Purified Wood Pulps

I. Furfural Analysis Methods

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All existing pentosan analysis methods are theoretically incapable of good precision when applied to highly purified cellulose pulps having pentosan contents in the neighborhood of 1% or less. This is primarily due to their use of macroanalysis methods for the estimation of the microquantities of furfural produced by the acid distillation of the pulps. A micromethod for the specific analysis of furfural is presently available employing aniline acetate. This work concerns the development of a highly sensitive and precise method for the analysis of furfural plus hydroxymethyl furfural which makes use of the similar ultraviolet absorption properties of these materials. The method is much faster and easier to use than any total aldehyde method now in use and requires only a fraction of the distillates. Tests on typical pentosan distillates have shown it to be considerably more precise than the TAPPI bromate titration procedure.

All methods used for pentosan determinations depend upon the formation of furfural when pentosans are boiled with dilute mineral acid. The acid used has generally been hydrochloric and the concentrations used generally 12%, although 18 to 20% acid was extensively used in earlier work. Beyond these basic points, however, there has been little agreement on procedure and a variety of methods have been proposed in the literature (*1*, *2*) for estimating the furfural produced by the action of acid on the pulps. None of the methods proposed have been applied to the distillates from pure pentosans and all must make empirical corrections for the presence of other furfural derivatives which are generally present in these distillates. All acid distillates of cellulose will, of course contain some hydroxymethyl furfural (from glucose and other hexoses produced by hydrolysis) and may contain methyl furfural as well, derived from the methyl pentosans possibly present in the pulps. Because of these factors no existing pentosans method can claim to be accurate but must instead be judged only on its reproducibility and the interpretation which can be made of its results.

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All of the existing standard macromethods for pentosan analysis can be shown to be *theoretically* incapable of good precision when applied to highly purified cellulose pulps having pentosan contents in the neighborhood of 1% or less. For example, by the standard TAPPI method (T 223 m-48) an error in titration of ± 0.1 ml. corresponds to an error of ±6.6% on a 1% pentosan pulp. Such a titration error must be expected as a minimum since the titration is an indirect one on about 600 grams of solution containing only 7.27 mg. of furfural. A net titration of less than 3 ml. is found for a 1% pentosan pulp, this figure being obtained by subtraction of the sample titration from a blank titration of about 40.0 ml.

That all other macromethods of furfural analysis must similarly fail to attain good precision when applied to a 1% pentosan pulp will be realized when one considers that the maximum furfural concentration in the usual 300 ml. of distillate is only 24.2 micrograms per ml. Obviously, some micromethod of analysis for furfural must be developed before either precision or accuracy can be obtained. It was the purpose of this work to develop such methods, and to then apply them to determine the optimum distillation conditions for precise pentosan analysis.

METHODS OF FURFURAL ANALYSIS

Three methods of instrumental analysis applicable to microgram quantities of furfural were tested, and their estimated relative sensitivities are given in Table I as compared with that of the TAPPI bromate-bromide titration procedure. These figures were estimated

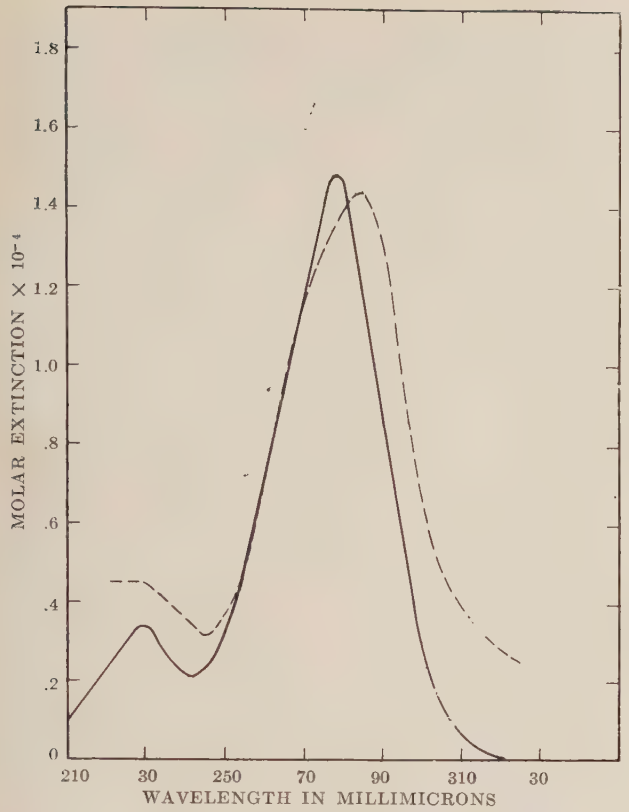

Fig. 1. Ultraviolet absorption curves of furfural and of hydroxymethyl furfural

Solid line—furfural. Dotted line—hydroxymethyl furfural

assuming optimum conditions and are given only to provide a relative comparison of the sensitivities of these methods. For example, it was assumed that by the TAPPI procedure a 10 ml. net titration would give 1% precision, while for the colorimetric and ultraviolet methods an instrument reading of 0.100 was assumed to be required for this precision. The colorimetric method mentioned in this table was essentially that of Adams and Castagne (*3*) using aniline acetate as the colorimetric reagent. The polarographic method was worked out very simply by neutralizing the acid distillates, buffering them with Na_2CO_3, and removing oxygen from them by the addition of Na_2SO_3. This method gave good results when applied to standard furfural solutions but was abandoned in favor of an ultraviolet absorption method which was found to be much easier to use as well as more precise.

The ultraviolet method (employing the Beckman Model DU spectrophotometer) was the simplest of all the methods to use and depends on the fact that furfural and hydroxymethyl furfural have essentially the same ultraviolet absorption spectrum. This is brought out in Fig. 1 in which the solid line represents the experimentally determined curve for furfural and the dotted line the absorption curve reported in the literature (*4*) for hydroxymethyl furfural. While theoretically the light absorption peak of a mixture of these two aldehydes should lie somewhere between 277.5 mmu (furfural) and 284 mmu (hydroxymethyl furfural), it was experimentally found that it made no significant difference in the results whether solutions were analyzed at 277.5 or at the experimentally determined maximum absorption point—which was occasionally found to shift slightly toward the longer wavelength.

Table I. Comparison of "Furfural" Analysis Methods[a]

Maximum furfural obtainable from a 1% pentosan	24.2 μg./ml.
Minimum furfural for 1% precision by TAPPI method	160.0 μg./ml.
Minimum furfural for 1% precision by polarographic method	10.0 μg./ml.
Minimum furfural for 1% precision by colorimetric method	4.0 μg./ml.
Minimum furfural for 1% precision by ultraviolet method	1.0 μg./ml.

[a] Only the colorimetric method analyzes specifically for furfural. The other methods give the total of furfural, hydroxymethyl furfural, and methyl furfural.

CALIBRATION OF ULTRAVIOLET METHOD

Standard solutions of freshly distilled furfural were made up in water solution and their extinction coefficients determined versus a water blank. The calibration data are summarized in Table II from which it will be seen that Beer's law is followed satisfactorily. As will be realized by anyone familiar with the Beckman

Table II. Calibration Data for Furfural Analysis by Ultraviolet Light Absorption

Solution concentration		*Extinction coefficient*	
μg./ml.	*Molarity × 10⁴*	*Observed*	*Molar × 10⁻⁴*
92.8	9.65	14.40	1.49
69.6	7.24	10.70	1.48
46.4	4.83	7.10	1.47
23.2	2.41	3.57	1.47
5.8	0.60	0.885	1.47
		Av. =	1.48

spectrophotometer, all but one of the observed extinction values shown in Table II were too high to be read directly, and so with the exception of the weakest solution shown, these extinction values were read on 1:10 dilutions of these samples. It has been found that in the range of pentosans in which we are presently concerned, from 0.2 to 2.0%, this same dilution should be made so that solutions to be analyzed are about 0.3 *N* with respect to HCl concentration. It has been found that this concentration of HCl does not affect the ultraviolet absorption of the samples so that the use of a water blank and the calibration curve indicated by Table II is justified.

COMPARATIVE RESULTS

To further show the validity of this new technique, its results were compared with those obtained by the TAPPI bromine titration procedure on pentosan distillates from 21 experimental dissolving grade wood pulps chosen at random. Since only 1 ml. of solution was required by the ultraviolet method, the two methods could be compared on the same distillate solutions by applying a minor (and probably insignificant) correction to the TAPPI results. The per cent pentosans shown for the ultraviolet readings were obtained by first predicting the titration result from the regression equation correlating titration with ultraviolet absorption, and then carrying out the usual TAPPI calculation. Thus, both sets of results were obtained using the usual empirical factors to correct for hydroxymethyl furfural and incomplete conversion of pentosan to furfural. These results are summarized in Table III. As will be seen from this tabulation, the range of pentosan contents covered was from 1 to 3%,

Table III. Comparative Results of Pentosan Analyses by TAPPI Bromine Titration and by Ultraviolet Absorption Analyses

TAPPI bromine titration results		*Ultraviolet analysis*	
Net titration, %[a]	*Pentosan, %*	*Optical density, %*	*Pentosan, %*
4.3	2.22	0.895	1.96
4.0	2.00	0.930	2.08
4.0	2.00	0.930	2.08
4.2	2.15	0.940	2.12
4.0	2.00	0.945	2.15
3.9	1.92	0.983	2.25
2.9	1.18	0.598	0.96
2.9	1.18	0.628	1.07
2.6	0.95	0.628	1.07
3.4	1.55	0.825	1.73
3.6	1.70	0.853	1.82
3.1	1.32	0.653	1.16
5.0	2.75	1.140	2.60
4.6	2.45	1.020	2.37
4.4	2.30	1.030	2.42
3.8	1.85	0.845	1.79
3.7	1.78	0.793	1.62
3.1	1.32	0.875	1.92
3.6	1.70	0.830	1.74
5.6	3.20	1.230	3.07
5.5	3.12	1.130	2.75

[a] Blank volume was approximately 40.0 ml. for all samples.

rather than below 1% in which latter range the use of the ultraviolet method is particularly advantageous. This was necessary for such a comparison, as below 1% pentosan content results by the TAPPI method are so erratic as to make any comparison of doubtful value.

DISCUSSION

Statistical analysis of the data in Table III showed that the two methods measure equal quantities of material—presumably furfural plus hydroxymethyl furfural. The correlation coefficient was +0.937, significance level >0.1%, slope of the regression line 1.01, and the standard deviation about the regression line 0.22% pentosan. The standard deviation of the TAPPI method replicate pentosan analyses in this range of concentration was found to be 0.26% pentosan and the standard deviation of the ultraviolet method was similarly found to be 0.05% pentosan. In addition, the ultraviolet method has several other important advantages over the TAPPI method in that it is: (1) faster and simpler to use, (2) requires no standard solutions, and (3) uses only a fraction of the acid distillates so that replicate values may be obtained when desired.

It will be recognized that the difference between the results of the colorimetric analysis, which measures only the furfural in these mixtures, and those of the ultraviolet method, which measures total furfural derivatives, should provide a reasonably accurate measure of the amount of foreign aldehydes (other than furfural) produced by the acid distillation of cellulose pulps. The quantity of hydroxymethyl furfural produced by the standard TAPPI distillation procedure has been estimated by several workers as about 8.4 micrograms per gram of pulp. This figure was arrived at by indirect measurements of doubtful precision, however, and was never intended to be applied to low pentosan pulps, for which an error in this average figure of 2 to 3 micrograms may represent as much as 100% error in the amount of pentosan calculated. It is also not known whether the amount of hydroxymethyl furfural evolved is influenced by the other properties of a pulp such as viscosity or alpha-cellulose content. Work is now under way in these laboratories designed to investigate these and other factors.

LITERATURE CITED

1. Wise, L. F., "Wood Chemistry," pages 611–625, New York, Reinhold Publishing Corp., 1944.
2. Doree, C., "The Methods of Cellulose Chemistry," pages 375–391, London, Chapman and Hall, Ltd., 1950.
3. Adams, G. A., and Castagne, A. E., *Can. J. Res.* 26: 314 (1948).
4. Scallet, B. L., and Gardner, J. H., *J. Am. Chem. Soc.* 67: 1934–1935 (1945).

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The Determination of Total Nonaqueous Constituents in Pulp Mill Liquors

Part II. Application to All Types of Residual Pulping Liquors

J. H. PHILLIPS and M. M. RUBRIGHT

A method for the determination of total water content, and by calculation, the total nonaqueous constituents in pulp mill residual liquors is described. This method, presented previously in a paper given before the Annual Meeting of TAPPI in February, 1951, was reported at that time preferable to existing methods for analyzing magnesium bisulphite residual liquors and has now been found applicable for determining moisture in all types of residual pulping liquors. This method employs the two-solution modification of the well-known Karl Fischer titration and gives rapid and reproducible results with a greater accuracy than oven-drying methods. A determination can be completed in a few minutes in contrast to the time-consuming oven-drying methods.

One of the principal problems confronting operators of pulp mill recovery processes is that of obtaining a reliable value for the total solids content of waste liquors. The total nonaqueous content of the liquor is the controlling figure in daily mill operations. Variations in the amounts of the specific constituents which make up the so-called solids content of the liquor are of minor importance in the present study. A more practical evaluation of the operating problem can there-

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fore be obtained by determining the moisture content of the liquor *per se*, and then by grouping all the other constituents, whether gaseous, liquid, or solid, under the classification of total nonaqueous constituents.

The classical definition of "total solids" of a liquor must therefore be extended to include the gaseous constituents and easily volatilized liquids usually lost in the various drying methods in daily use in many mills. Such a definition was proposed in the original paper (*1*) as follows: "The total nonaqueous constituents of a liquor shall, as the name implies, include all constituents, either organic or inorganic, present in elemental form or combined in any compound of any physical state, gaseous, liquid, or solid, other than the chemical compound water."

Therefore, by the above definition, a liquor should no longer be thought of as being divided into the two more or less arbitrary fractions, "dried residue" and "volatile matter," resulting from oven-drying methods at an arbitrarily chosen temperature. The method previously presented and discussed herein for determining the true water content of a liquor separates this component from the total nonaqueous constituents and provides a much more logical grouping of liquor constituents. This method therefore yields more significant and useful data for application in subsequent engineering calculations.

Since the original paper proved the method satisfactory for determining moisture in magnesium bisulphite liquor, the immediate problem involved in this particular study was to determine the feasibility of applying this method to other types of residual liquors including those from calcium, ammonia, kraft, and semichemical processes and to establish any possible modification in the method necessary for analyzing these types of residual liquors.

PREVIOUS WORK

A bibliography of previous methods for moisture determinations and a discussion of them was presented in the first paper (*1*). Several articles dealing with the use of the Karl Fischer reagent have been published since that time. A. G. Jones (*2*) and J. Mitchell, Jr. (*3*) have written reviews of the status of the Karl Fischer titration to date. A round-table discussion of the Fischer titration by J. Mitchell, Jr., W. Seaman, and L. R. Kangas (*4*) has been recorded.

Johannson (*5*) proposed the two-solution modification originally, and recently (*6*) proposed two additional variations on his original method. Mitchell (*3*), however, stated that this extension of technique increased the time requirement and probably did not significantly improve the sensitivity of the analysis. The Karl Fischer titration was again reported recently for use in determining water in petroleum products, oils, fats, waxes, explosives, paints, polymeric materials, soap, foodstuffs, and carbohydrates (*3*), xanthates and dithiocarbonates (*7*), hydrogen chloride (*8*), oils (*9*), and sulphuric acid (*10*). There has been no work published by other authors reporting the reagent's application to pulping liquor analysis except those mentioned in the previous paper (*11*).

EXPERIMENTAL

It was well established in our previous paper that the Karl Fischer titration method could be satisfactorily modified to analyze magnesium-base and weak calcium-base liquors for their water content. In the present study all other types of residual pulping liquors were analyzed for their water content by various other adaptations with the exception of liquors from the soda process since such liquors were not readily available. However, since soda liquors are similar to kraft liquors with a lower content of highly volatile sulphur constituents, the application to them should cause no difficulty.

For the application of the Karl Fischer titration to residual pulping liquors the regular reagent, a solution of iodine, sulphur dioxide, and pyridine in absolute methanol, is divided into two solutions, one a solution of pyridine and sulphur dioxide in methanol, and the other a solution of iodine in methanol. The sample is dissolved, or suspended, in the methanol solution of pyridine and sulphur dioxide, and titrated with the iodine solution. The iodine solution is previously standardized against known weights of water. The end point of the titration is determined electrometrically by the *dead-stop end-point method.*

Study of the Titration

It was found necessary to investigate certain aspects of the titration because of a lack of sufficient published information on the two-solution method. These aspects were (1) the proper diluent to use for dissolving or suspending the sample during the iodine-consumption corrective titration, (2) the stoichiometric relationship between water and the pyridine-sulphur dioxide solution, and (3) the per cent of reaction between water and iodine during the titration.

While this modification of the Karl Fischer titration has been mentioned by other authors (*2, 3, 4, 12*), and has been proved stoichiometrically correct (*13*), no mention has been made of one advantage it has over the standard Karl Fischer method, namely, that this two-solution reagent modification can be used for analyzing samples that interfere with the standard Karl Fischer reagent, because a corrective titration can be performed. The standard Karl Fischer titration cannot be used for analyzing samples having the complex mixture of iodine-consuming organic constituents present in residual liquors, because it would be difficult to calculate the correction factor necessary, even if the exact amounts of these interfering constituents could be determined. In the two-solution method such iodine-consumption corrections are easily found by using the same iodine solution under essentially the same conditions that are present in the water titration.

All kraft liquors, and certain samples of other liquors, require a correction for the iodine consumed by side reactions with constituents other than water in the sample. This is done by titrating the sample, suspended in a diluent, with the solution of iodine in methanol, using the electrometric end point. This correction is subtracted from the total volume of iodine solution used in the water titration.

In order to duplicate the titration for water as closely as possible it would be desirable for the diluent to contain two of the three components present in the titrating medium (sulphur dioxide, pyridine, and methanol). Obviously all three components cannot be used or the

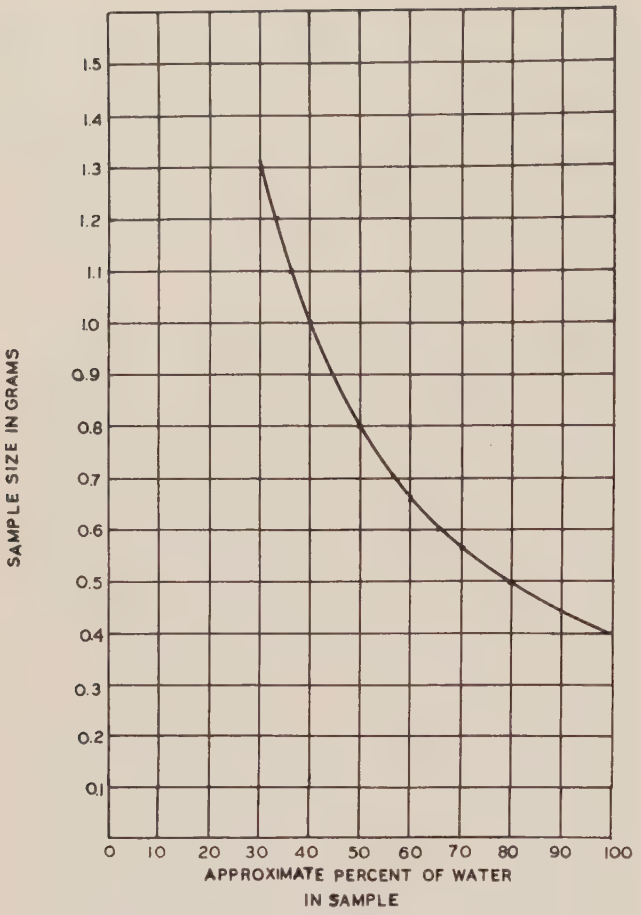

Fig. 1. Maximum allowable sample size

titration for water would result. Sulphur dioxide cannot be used alone since it is a gas. Sulphur dioxide and methanol cannot be used together since the gas will not dissolve in methanol in sufficient quantity for this application. Sulphur dioxide is quantitatively absorbed by pyridine, but this combination cannot be used because the iodine solution used for titrating is a solution of iodine in methanol, and this methanol and the sulphur dioxide and pyridine will react with the water in the sample. This leaves the combination of methanol and pyridine as the theoretically ideal titrating diluent.

To determine if the use of methanol alone would give the same iodine-consumption correction as methanol and pyridine used together as a diluent, iodine-consumption corrective titrations were carried out on a weak kraft liquor. The results of these titrations revealed that using methanol alone, 0.725 ml. per gram sample of solution II was required, while methanol plus pyridine required 0.671 ml. per gram sample. These results were considered to agree well enough to warrant the use of methanol alone as a diluent on samples of less than 1 gram since under these conditions the difference between the results of the two diluents could not be read on the burets.

Since water has no effect on the titration for iodine consumed by side reactions, it was considered as a diluent for the sample used for iodine-consumption titrations. It was found, however, that the use of water caused excessive foaming with kraft liquor samples, and the difficulties resulting therefrom demonstrate the desirability of using methanol.

In this titration, or any other Karl Fischer titration, the following equations apply:

$$I_2 + SO_2 + 3C_5H_5N + H_2O \rightarrow 2C_5H_5NHI + C_5H_5N\langle \overset{SO_2}{\underset{O}{|}} \rangle \quad (1)$$

$$C_5H_5N\langle \overset{SO_2}{\underset{O}{|}} \rangle + CH_3OH \rightarrow C_5H_5N\langle \overset{H}{SO_4CH_3} \quad (2)$$

In such a titration all five components are necessary, and must all be present simultaneously to permit the above reactions. In this method, an excess of solution I is present—namely pyridine, sulphur dioxide, and methanol. When water is present under these conditions the water will react as the iodine is added, until all the water has reacted. The next drop of iodine will then be unchanged and will indicate a true end point. If, however, the water is present in excess of the stoichiometric amount of pyridine-sulphur dioxide solution, the iodine will react with the water until the pyridine-sulphur dioxide is exhausted, and then will react no further, regardless of the amount of water present, leading to a false end point. It is therefore necessary to know the amount of water with which a fixed volume of the pyridine-sulphur dioxide solution can react in order to properly establish the maximum size of the sample.

Because of practical size limitations on the titration chamber it was necessary to choose a 20-ml. portion of the pyridine-sulphur dioxide reagent as the optimum volume. To find the maximum limit of water equivalent to this volume of reagent, the following procedure was followed. To 20 ml. of the pyridine-sulphur dioxide solution, weighed drops of water were added intermittently with alternate titrations with the iodine solution. The equivalence of the iodine solution was calculated by the following equation.

$$\frac{\text{Weight of water added}}{\text{Milliliters of solution II used}} = \text{Equivalence of solution II} \quad (3)$$

As long as the pyridine-sulphur dioxide reagent was

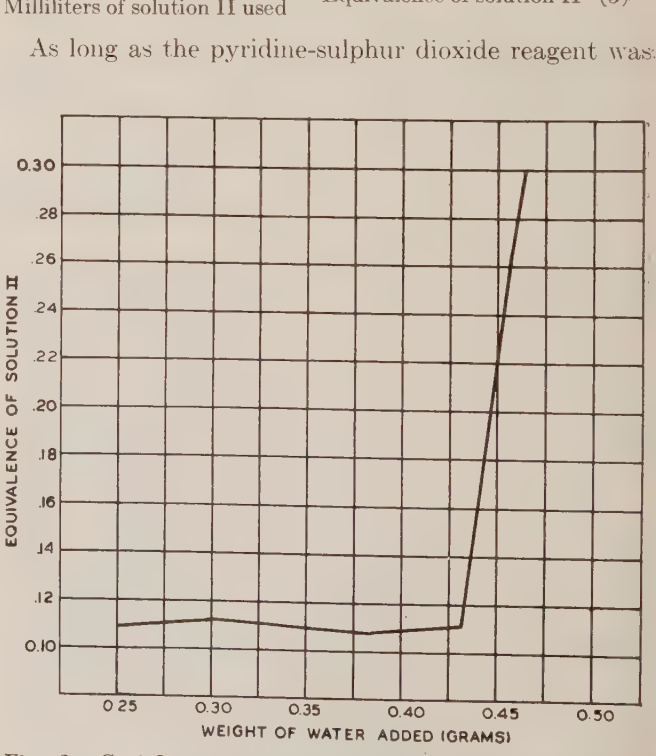

Fig. 2. Stoichiometric relationship between water and solution I

in excess of the water, these equivalences remained constant. When a quantity of water in excess of the stoichiometric equivalent of the pyridine solution was added, the iodine solution did not react with the water, and a false end point resulted. Thus there is a marked increase in the apparent equivalence of the iodine solution as indicated in Table I and on Fig. 1. In this manner, the stoichiometric relationship between water and the pyridine-sulphur dioxide solution was found.

Table I. Stoichiometric Relationship Between Water and Solution I (20 Ml. of Solution I Used)

Addition No.	*Weight of water added, g.*	*Solution II needed, ml.*	*Equivalence solution II, col. 2/col. 3*
1	0.2503	22.6	1 ml. = 0.01107 g. H_2O
2	0.0546	4.8	1 ml. = 0.01137 g. H_2O
3	0.0785	7.2	1 ml. = 0.01090 g. H_2O
4	0.0502	4.5	1 ml. = 0.01115 g. H_2O
Total	0.4336	Av.	1 ml. = 0.01112 g. H_2O
5	0.0578	1.9	1 ml. = 0.03042 g. H_2O

It can be seen from Table I that up to a total of 0.4 gram of water the equivalence of solution II remains practically constant. When more than 0.4 gram is added a marked departure from the average equivalence value occurs. This established the maximum amount of water with which 20 ml. of the solution could react as about 0.4 gram. The size of a sample containing 85% moisture is thereby limited to 0.45 gram, and one containing 50% moisture to 0.8 gram as shown in Fig. 2. This is a fortunate coincidence, because, using the concentration of iodine solution mentioned in the description of the method, the maximum sample size established above requires no more than 40 to 42 ml. of the iodine solution, avoiding the necessity for refilling the buret during the titration.

To further prove the validity of the method, a series of titrations was carried out to determine how much water could be recovered by titration when it was added to weighed samples of a magnesium bisulphite liquor. The results are listed in Table II and shown graphically in Fig. 3. The moisture content by titration of the original liquor was 43.7%. The table shows that all the water, within experimental errors, was recovered.

Some slight modifications of this method are necessary when analyzing certain types of liquors. The use of glacial acetic acid as an aid in dissolving and suspending concentrated calcium-base liquors was found necessary and was justified for several reasons. The use of an acid or neutral diluent is necessitated by the acidic nature of the liquor. Any basic diluent would react with the acidic part of the liquor, forming water which would be titrated and result in erroneous values. Glacial acetic acid is the most readily available inexpensive acid which is sufficiently anhydrous and compatible with the sample. The use of acetic acid has been mentioned in the literature as necessary in the Karl Fischer titration for water in amines, and apparently gave no interference with the reagent (*3*).

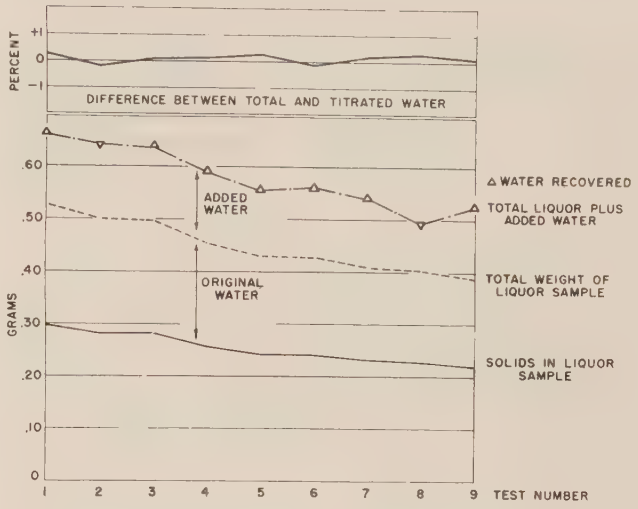

Fig. 3. Water recovered by titration

In our procedure, if interference occurs, correction is automatically made for it in the titration for the blank.

Experimental Results

As a preliminary step, a comparison of results of moisture determinations on all types of liquors analyzed by the TAPPI oven-drying method and the titration method was made. A variation of the TAPPI standard oven-drying procedure which is used in the authors' laboratory was also used for further comparison. Table III lists the results of this series of tests. The samples listed here are described as follows: A through C are kraft liquors, D is a semichemical process liquor, E and F are magnesium-base liquors, G is a calcium-base liquor, and H and I are ammonia-base liquors. It is felt that these samples give a representative picture of the relationship among the three values reported. The kraft liquors were analyzed by TAPPI methods following the procedure outlined in TAPPI Standard T 625 m-48, consisting of heating an accurately weighed 10-ml. portion of the liquor in a porcelain evaporating dish at 105 ± 2°C. for 24 hr. The other liquors, including the semichemical and ammonia-base liquors for which no standard procedures are listed, were analyzed for moisture by the TAPPI Standard for Sulphite Liquors T 629 m-48 which entails placing a 10-ml. por-

Table II. Water Recovered by Titration When Added to a Liquor Sample Containing 43.7% Original Water

No.	*Liquor sample weight, g. (weighed)*	*Water in liquor (col. 2 × % H_2O)*	*Added water, g. (weighed)*	*Total water titrated, g.*	*Added water recovered by titration (col. 5 − col. 3)*	*Added water recovered, % [(col. 6 × 100)/col. 4]*
1	0.4096	0.1789	0.1311	0.3105	0.1316	100.4
2	0.4543	0.1974	0.1368	0.3346	0.1372	100.2
3	0.4298	0.1877	0.1247	0.3135	0.1258	100.9
4	0.4028	0.1759	0.0887	0.2654	0.0895	100.9
5	0.3896	0.1701	0.1341	0.3045	0.1344	100.2
6	0.4999	0.2183	0.1428	0.3602	0.1419	99.4
7	0.4982	0.2176	0.1376	0.3556	0.1380	100.3
8	0.5267	0.2299	0.1338	0.3648	0.1349	100.8
9	0.4291	0.1874	0.1337	0.3209	0.1335	99.8

tion in a covered crucible of 35 ml. capacity, heating on a steam bath until the bulk of the moisture is removed, and then placing in an oven for 24 hr. at 105°C. The oven-drying method used in the B&W Laboratory involves drying the sample to constant weight on oven-dried crystalline alumina in a porcelain crucible in an oven at 105 ± 2°C. The titration method used is described later in this paper.

It is seen that, in general, the results of the two oven-drying procedures are comparable except with sample C where the drying time should obviously be greater than the 24 hr. specified by TAPPI. Any other slight differences are probably due to the arbitrary drying time of the TAPPI method, but do not negate any comparisons which can be drawn from the other tables in this paper.

Since there is generally close agreement between the two oven-drying methods above, it was decided to compare the results of all samples analyzed by the titration method with those obtained by the B&W oven-drying procedure. No special care was taken to treat these samples any differently from others run in the laboratory, since it was felt that for comparison work the samples should be run routinely by both methods.

Table IV shows results of determinations made on weak kraft liquors.

It may be noticed that in most of the determinations reported in Table IV, values obtained by the oven-drying procedure are lower than the titration values. Two conditions that have been recognized by other investigators as sources of error in oven-drying techniques may account for the above variation. The loss of volatile constituents during heating leads to an apparent increase in water content in the sample while the retention of water of crystallization in the oven-dried residue decreases the apparent moisture content. These factors led us to seek a method based on some principle which avoided these possible errors.

The loss of volatile matter cannot be determined directly, but the retention of water of crystallization can be determined by the titration method described here. A typical weak kraft liquor was oven dried for 24 hr. at 105°C. in one of the titration jars. This drying procedure is similar to the TAPPI method. When the residue was then titrated for retained moisture it was found that 0.33 to 0.37% moisture had been retained in the dried material.

Additional evidence in support of this moisture retention in the oven-dried residue will be found in the discussion of concentrated liquor where volatile material is at a minimum and the percentage of solid material that can retain moisture is increased.

It was thought that another source of error might be present in oven-drying methods. This is the oxidation of various sulphur compounds in some liquor samples to sulphate sulphur. The sulphate sulphur content of an unoxidized weak kraft liquor was determined before and after oven drying at 105°C. The sulphate content before drying was 0.00260 gram sulphate sulphur per gram of liquor, and after drying was 0.00352 gram per gram of liquor. This change is equivalent to 30% increase in sulphate content and when expressed in terms of sample weight, amounts to 0.1%. This will

Table IV. Comparison of Values for Moisture Obtained by Oven Drying and by Titration of Weak Kraft Liquors

	Oven-drying method		*Titration method*	
No.	*% H_2O*	*% H_2O av.*	*% H_2O*	*% H_2O av.*
A	85.4	85.4	86.3	86.0
	85.4		86.2	
	85.4		85.8	
			85.7	
			85.6	
			86.4	
B	85.0	84.9	85.5	85.6
	84.9		85.8	
	84.9		85.2	
			85.6	
			85.6	
C	89.1	89.1	89.8	89.6
	89.0		90.0	
	89.2		89.4	
			89.3	
			89.8	
			89.4	
			89.3	
D	84.9	84.8	86.0	86.2
	84.8		86.0	
	84.8		86.7	
E	83.6	83.5	85.4	85.7
	83.5		85.7	
	83.6		85.9	
			85.9	

Table III. Comparison of Values for Moisture in Residual Liquors Obtained by Different Methods

Sample No.	*Description of sample*	*TAPPI method, %*	*Av., %*	*Modified TAPPI method, %*	*Av., %*	*Titration method, %*	*Av., %*
A[a]	Weak kraft	82.6	82.6	83.3	83.3	83.3	83.3
		82.5		83.3		83.2	
B	Weak kraft	81.6	81.6	82.5	82.5	83.0	83.1
		81.6		82.6		83.2	
C	Conc. kraft	39.6	40.1	47.7	47.8	49.3	49.2
		40.7		48.0		49.1	
D[b]	Semichemical	89.7	89.6	89.5	89.5	89.2	89.3
		89.6		89.5		89.3	
E	Weak Mg-base	84.6	84.5	85.0	85.0	83.7	83.7
		84.5		85.0		83.7	
F	Conc. Mg-base	47.1	47.1	47.4	47.3	46.1	45.9
		47.2		47.3		45.8	
G	Conc. Ca-base	42.2	42.0	42.0	41.9	40.9	41.0
		41.8		41.7		41.0	
H	Conc. NH_4-base	50.3	51.3	52.9	52.6	47.6	47.6
		52.3		52.3		47.7	
I	Conc. NH_4-base	48.0	47.9	47.0	47.1	44.2	43.9
		47.8		47.3		43.9	
						43.6	

[a] TAPPI Method T 625 m-48 used for samples A through C.
[b] TAPPI Method T 629 m-48 used for samples D through I.

have the same effect as retention of water of crystallization, hence indicating a lower apparent moisture content.

The effect of these three sources of error depends upon each individual liquor. Liquors having a low solids content and a high volatile matter content will give a higher apparent moisture content by oven-drying methods than the titration method. Samples which have been oxidized before testing will give lower apparent moisture values by oven drying than by the titration method, because of the oxidation of volatile sulphides to less volatile sulphur compounds, some of which exhibit a greater tendency to retain water of crystallization during evaporation.

Table V gives the results obtained on concentrated kraft liquor samples. In this case the differences between titration and oven-drying values are more pronounced than those in the weak kraft liquors. This difference is logical—more solids are present, and more opportunities exist for water of crystallization to be retained in the oven-drying method. This same trend was indicated by Johannson in the only sample reported in his paper (*5*).

An idea of the amount of the residual moisture retained in the dried material from concentrated liquor was gained by titrating the oven-dried residue for this moisture in the same manner as was done on the weak kraft liquors mentioned above. The results indicate a retention of as much as 3.1% residual moisture in the residue after oven drying.

Table V. Comparison of Values for Moisture Obtained by Oven Drying and by Titration of Concentrated Kraft Liquors

Sample No.	*—Oven-drying method—* % H_2O	% H_2O av.	*—Titration method—* % H_2O	% H_2O av.
A	45.3	45.3	47.1	47.0
	45.2		46.6	
	45.3		46.9	
			47.2	
			46.8	
			46.8	
			46.9	
			47.0	
			47.1	
			47.4	
			47.1	
B	49.0	49.1	51.5	51.7
	49.2		51.8	
			51.9	
C	38.6	38.6	39.3	39.3
	38.6		39.1	
	38.7		39.6	
D	51.2	51.2	52.9	52.7
	51.2		52.6	
E	30.4	30.8	33.3	33.4
	31.1		33.5	
	31.1			
F	26.4	26.2	30.3	30.2
	26.2		30.2	
	25.9			
G	38.1	37.8	39.2	39.1
	37.9		39.0	
	37.5			
H	51.7	51.8	53.0	53.0
	51.9		53.0	
	51.8			
I	43.1	42.8	45.0	44.9
	42.8		44.8	
	42.6			
J	43.9	44.1	46.4	46.4
	44.0		46.4	
	44.4			
K	28.0	28.2	30.7	30.8
	28.4		30.9	

The apparent absence of volatile matter in this liquor is explained by the very nature of the sample—it was obtained after the mill evaporation of a weak liquor. In this evaporation most of the volatile material was driven off. The oxidation of sulphide type compounds evidently took place at the same time since no increase in sulphate sulphur content was found in the oven-dried residues.

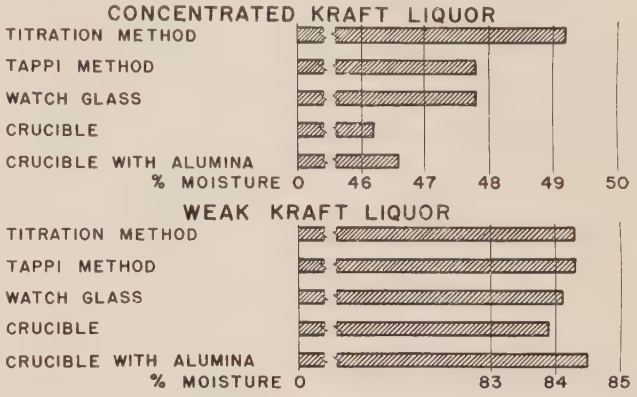

Fig. 4. Effect of container on oven drying

Slight differences of procedure in oven-drying methods exist in various paper mills in this country. The variation in the results caused by the characteristics of the container and the absence or presence of a supporting medium in the oven-drying procedure is shown by Table VI and shown graphically in Fig. 4. It is noticed that the difference in technique makes only a small difference in results in the case of weak liquor, but has a profound influence upon the results from concentrated liquor samples.

Table VII contains results obtained with semichemical pulp liquor samples. It may be noted in the high moisture and low solids samples that the oven-dried moisture value is near that of the titration value, and in one case, even higher than the titration value, and that the differences between the two sets of values become slightly more evident as the amount of solids increases. In the samples containing large percentages of water the effect of the loss of volatile constituents tends to cancel the effect of retention of moisture as water of crystallization. In concentrated liquors, the amount of volatile constituents is low and the effect due to water retention increases. It is noted that, because of these two opposing factors, the difference between titration and oven-drying values is not as great as it is in kraft liquor in the same range of moisture content.

Table VI. Effect of Characteristics of Container Upon Values Obtained by Oven Drying

	% H_2O
Concentrated kraft liquor	
Titration	49.2
TAPPI method—evaporating dish	47.8
Watch glass—24 hr. at 105°C.	47.8
Crucible—24 hr. at 105°C.	46.2
Crucible—with alumina—24 hr. at 105°C.	47.6
Weak kraft liquor:	
Titration	84.3
TAPPI method—evaporating dish	84.3
Watch glass—24 hr. at 105°C.	84.1
Crucible—24 hr. at 105°C.	83.9
Crucible—with alumina—24 hr. at 105°C.	84.5

Table VII. Comparison of Values for Moisture Obtained by Oven Drying and by Titration of Semichemical Liquors

Sample No.	Oven-drying method		Titration method	
	% H_2O	% H_2O av.	% H_2O	% H_2O av.
A	91.4	91.5	92.0	91.7
	91.6		91.7	
	91.6		91.8	
			91.5	
B	89.3	89.3	88.8	88.7
	89.2		88.8	
	89.3		88.4	
C	54.0	54.1	55.2	55.1
	54.1		55.0	
	54.3			
D	45.3	45.1	45.3	45.2
	45.0		45.2	
	45.0			
E	37.1	37.2	38.3	38.2
	37.4		38.2	
	37.1		38.1	
F	37.2	37.1	38.5	38.8
	36.9		39.1	
	37.1			
G	36.1	36.1	36.0	36.0
	36.1		36.0	
	36.2			
H	29.3	29.1	27.7	27.8
	29.0		28.0	
	28.9			

Table VIII contains results obtained on samples of calcium-base liquors and ammonia-base liquors. Samples A and B are calcium-base liquors and samples C, D, E, and F are ammonia-base liquors. The close agreement between oven-drying and titration methods in the case of the evaporated calcium-base liquor is probably due to the canceling of two opposing factors—the loss of volatile materials and the retention of water of crystallization in the oven drying.

Table VIII. Comparison of Values for Moisture Obtained by Oven Drying and Titration on Calcium and Ammonia-Base Liquors

Sample No.	Oven-drying method		Titration method	
	% H_2O	% H_2O av.	% H_2O	% H_2O av.
	Calcium-Base Liquors			
A	91.2	91.1	90.7	90.8
	91.1		90.7	
	91.1		90.9	
B	40.7	40.6	41.4	41.5
	40.8		41.3	
	40.3		41.5	
			41.7	
			41.7	
	Ammonia-Base Liquors			
C	86.7	86.6	84.6	84.7
	86.6		84.8	
	86.6			
D	55.4	55.4	51.0	51.0
	55.5		51.0	
E	52.9	52.6	47.6	47.6
	52.3		47.7	
F	47.0	47.1	44.2	43.9
	47.3		43.9	
			43.6	

The large discrepancies in the case of the ammonia-base liquors are due primarily to the loss of volatile materials from the liquor during oven drying, plus the fact that the ammonium salts in the liquor do not retain as much water of hydration as the sodium, calcium, and magnesium-base liquors, so that the effect of the loss of volatile materials is not canceled to the extent to which it is in other types of liquors.

Table IX lists samples which have been analyzed in our laboratory by both methods in a series of comparison tests which have been conducted over the last 2 years. These analyses have been made by various analysts in a routine manner. For convenience this table is arranged in descending order of water content as found by titration and again shows the variations between results which have been noted in the previous tables. It can be seen that both the magnitude and direction of the difference between results depend not

Table IX. Comparison of Per Cent Moisture by the Oven-Drying and Titration Methods

Titration	Oven drying	Difference from titration	Titration	Oven drying	Difference from titration
		Kraft Liquor			
92.2	91.7	−0.5	43.2	42.9	−0.3
87.5	86.3	−1.2	43.0	40.7	−1.3
85.6	85.5	−0.1	42.8	40.7	−2.1
85.0	82.4	−2.6	42.4	40.4	−2.0
84.0	82.9	−1.1	42.4	40.2	−2.2
83.6	83.5	−0.1	42.3	42.0	−0.3
81.3	81.4	+0.1	42.2	40.8	−1.4
58.4	57.2	−1.2	41.6	39.9	−1.7
51.5	49.2	−2.3	40.9	39.1	−1.8
49.7	48.2	−1.5	40.9	38.9	−2.0
49.7	47.3	−2.4	40.9	38.6	−1.3
48.2	46.5	−1.7	40.4	40.1	−0.3
48.2	46.1	−2.1	40.4	37.4	−3.0
48.1	46.9	−1.2	40.3	38.6	−1.7
47.1	45.7	−1.4	40.2	40.1	−0.1
47.0	44.8	−2.2	40.2	38.4	−1.8
46.4	45.3	−1.1	40.1	38.3	−1.8
46.4	44.5	−1.9	39.6	38.6	−1.0
45.9	43.2	−2.7	39.3	38.7	−0.6
45.6	43.8	−1.8	39.2	37.4	−1.8
45.0	43.8	−1.2	39.1	37.8	−1.3
44.9	43.8	−0.9	39.0	38.8	−0.2
44.6	42.1	−2.5	38.8	37.0	−1.8
44.6	42.0	−2.6	38.2	37.1	−1.1
43.8	41.6	−2.2	37.2	35.2	−2.0
43.8	41.2	−2.6	37.1	35.4	−1.7
43.8	40.9	−2.9	36.9	35.8	−1.1
43.7	42.4	−1.3	36.4	35.6	−0.8
43.5	41.2	−2.3	35.2	34.9	−0.3
43.3	42.4	−0.9			
		Magnesium Bisulphite Liquor			
94.6	95.2	+0.6	84.4	86.5	+2.1
88.5	89.3	+0.8	84.3	85.7	+1.4
85.8	87.0	+1.2	84.2	85.2	+1.0
85.7	86.5	+0.8	84.2	84.8	+0.6
85.6	86.0	+0.4	84.0	84.0	0.0
85.5	86.8	+1.3	82.6	82.5	−0.1
85.5	85.9	+0.4	81.7	80.9	−0.8
85.2	85.9	+0.7	67.4	68.3	+0.9
85.1	85.8	+0.7	46.0	45.8	−0.2
84.9	86.1	+1.2	45.8	46.3	+0.5
84.9	85.7	+0.8	45.1	45.1	0.0
84.6	85.0	+0.4	43.1	41.7	−1.4
84.5	85.1	+0.6	42.3	42.6	+0.3
		Calcium Bisulphite Liquor			
92.4	92.7	+0.3	46.0	46.6	+0.6
89.8	90.9	+1.1	42.4	42.4	0.0
46.4	46.5	+0.1	25.9	25.9	0.0
46.3	47.9	+1.6			
		Ammonia Bisulphite Liquor			
45.9	49.0	+3.1			
		Semichemical Process Liquor			
88.8	88.6	−0.2	81.5	80.9	−0.6
88.7	89.3	+0.6	68.2	67.3	−0.9
87.4	87.3	−0.1	41.3	40.2	−1.1
85.7	85.7	0.0	39.8	37.7	−2.1

only upon the type of liquor analyzed, but also upon the percentages of solids in the liquor.

Figures 5 and 6 are constructed from some of the data tabulated in Tables VIII and IX. The results obtained by the oven-drying and the titration methods as shown in Fig. 5 clearly indicate the magnitude of the errors introduced by the loss of volatile material

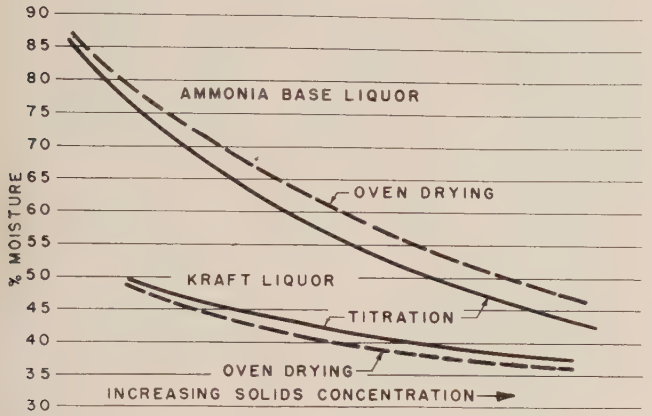

Fig. 5. Comparison of moisture determined by titration and oven-drying methods

from ammonia-base liquors analyzed by the oven-drying procedure. It can also be seen that this variation of results obtained by the two methods on kraft liquors is not only smaller in magnitude, but is also reversed in direction. Kraft liquors undoubtedly contain smaller amounts of volatile constituents and more inorganic salts capable of retaining water of crystallization in the oven-dried residue.

It can be seen from Fig. 6 that this difference in results obtained by the two methods is in the same direction as the ammonia-base liquors but is much less in magnitude. Magnesium-base liquors would be expected to contain less volatile constituents than ammonia-base liquors. Furthermore, less water was found to be retained in the oven-dried residue of magnesium-base liquors than in the corresponding residue from kraft liquors. Because of this lower retention of water by the oven-dried residue from magnesium-base liquors, the apparent increase in oven-drying moisture values due to loss of volatile matter is not affected as much as it is in kraft liquors. This results in the oven-drying moisture being higher than titration moisture in magnesium-base liquors.

It should be emphasized that, although the data presented in this paper comparing results obtained by the oven-drying and titration methods have been carefully examined, no empirical correction has been found satisfactory for conversion of oven-dried values for moisture into titration values, or conversely. Although the difference between the two values may be approximately constant for many liquors of the same type, other liquors from the same pulping process will show considerable variation from this average even though they are in the same approximate moisture content range. This variation is unpredictable and is probably due to differences in the type and amount of volatile constituents present in the residual liquor from different kinds of wood, or from a variation of the inorganic compounds in the residual liquor that can retain a varying amount of water crystallization in the oven-dried residue.

It will be noted that, although the reproducibility of titration values for moisture shows greater deviation than oven-drying values in analysis of successive aliquots of weak kraft liquors, the spread of these titration deviations generally becomes smaller when concentrated liquors are analyzed. Larger sample weights can be used for concentrated liquor analysis due to the lower total water content of the liquor sample, and thus experimental errors are decreased. The generally good reproducibility of results from kraft liquor analysis by oven-drying methods is explained by the large sample size used. However, this apparent advantage is offset by the errors routinely introduced by the oven-drying procedure. The volatile constituents present in ammonia-base liquors prevents reproducibility in the determination of moisture by an oven-drying procedure.

METHOD OF ANALYSIS

Reagents Required

1. Solution I. Mix 300 ml. C.P. pyridine and 300 ml. absolute, acetone-free, methanol. Add 60 grams of sulphur dioxide. This is most easily done in the following manner: pour the methanol and pyridine into a bottle or beaker and place on a pan balance. Connect a delivery tube to the sulphur dioxide supply and extend the other end of it to the bottom of the methanol-pyridine container. Add weights on the balance until the system is balanced, than add an additional weight of 60 grams. Add sulphur dioxide until balance is again restored. The solution is unstable immediately after being prepared but becomes stable on being stored overnight. Keep in a glass-stoppered bottle.

2. Solution II. Dissolve 180 grams of C.P. resublimed iodine in 1 liter absolute, acetone-free, methanol. Store in a glass-stoppered bottle. This solution has an equivalence of 1 ml. equals approximately 0.01

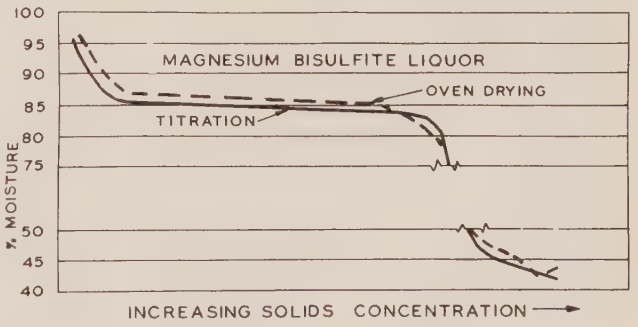

Fig. 6. Comparison of moisture determined by titration and oven-drying methods

gram of water. Less concentrated solutions can be used for samples containing small percentages of water.

3. Glacial Acetic Acid, Reagent Grade.

4. C.P. Absolute Methanol, Acetone-Free.

5. C.P. Glycerine.

Apparatus

Apparatus required includes a titration assembly which provides for two accurately calibrated burets for introducing the two reagents, and an end-point de-

tecting apparatus consisting of a dry cell, a variable resistance, a microammeter, and two platinum electrodes.

Figure 7 shows a plan view and front and side elevations of the titrating assembly which are self-explanatory. The framework is made of sheet Plexiglas which in turn is fastened to the titration stand. The bottle is a standard wide-mouth, screwcap, bottle with lid fastened to the Plexiglas and drilled to accommodate two buret tips, two platinum wire electrodes, and the glass stirrer.

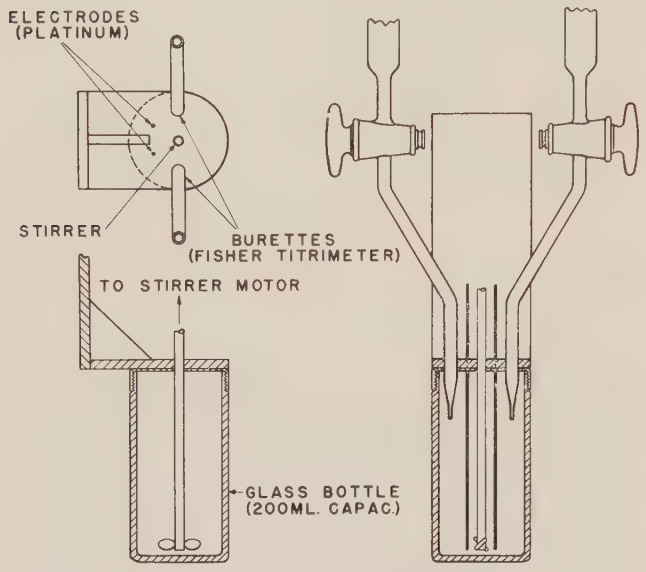

Fig. 7. Titration assembly

Figure 8 shows the wiring diagram of the end-point detecting assembly. This assembly differs from the one reported in the previous paper in that the galvanometer has been replaced by a more rugged microammeter. The microammeter used in this assembly has a range of 50 microamp. and is made by Roller-Smith, Style 116094-A, Type QX-27.

Standardization of Reagents

Since it is difficult to store these reagents for any length of time without small moisture pickup, it is necessary to standardize solution II each day before starting titrations on unknown samples. This standardization is performed as follows: to approximately 20 ml. of solution I in the titration bottle, add solution II from a buret, 1 ml. at a time, until the end point is approached, then dropwise to the end point as described below. Record the volume of solution II used. Add an accurately weighed amount of water as described below (using a solution II of the concentration specified above, a convenient weight to use is about 0.3 gram, requiring about 30 ml. of the solution to reach the end point), to the solutions in the titrating bottle and continue the addition of solution II until the end point is obtained. Record the volume of solution II used in the second titration. The equivalence of solution II is calculated as previously set forth in equation (3):

$$\frac{\text{Weight of water used}}{\text{Milliliter of solution II used}} = \text{Equivalence of solution II} \quad (3)$$

Determine the weight of the water mentioned above by weighing a medicine-dropper stoppered bottle containing a quantity of water; transfer an approximate amount of water from the dropping bottle to the titration bottle with the dropper and reweigh the dropping bottle and contents. The difference between the first and second weights of this bottle will provide the sample weight.

Detection of End Points

Start the stirrer motor, and adjust the variable resistance so that the potential between the platinum electrodes produces a deflection of about 10 microamp. on the microammeter. Proceed with the titration with solution II. As the end point is approached, the ammeter needle starts to swing, and at the end point maximum deflection is obtained. To insure that the end point has not been exceeded, turn off the stirrer motor. If the end point is a true one, the needle slowly drifts back to a minimum deflection and rises to maximum deflection when the stirrer motor is again started. If the end point has been exceeded, the needle remains steady at maximum deflection when the stirrer motor is turned off.

Determination of the Iodine-Consumption Correction

Since side reactions occur in some of these waste liquors upon titration with solution II, it is necessary to determine the iodine-consumption correction of these liquors so that the amount of iodine consumed by these side reactions can be subtracted from the total water titration value to compute the water content of the sample.

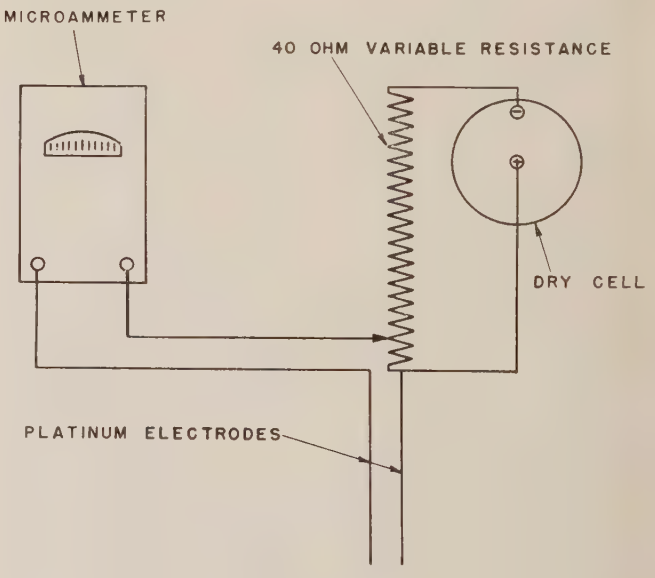

Fig. 8. End-point detecting assembly

Transfer an exactly weighed sample of the liquor to a clean titration bottle and dilute with 20 ml. absolute methanol. Stir until the liquor is completely dissolved or suspended. Turn on the stirrer motor and adjust the microammeter needle at 10 microamp. Titrate with solution II until the ammeter needle shows its first rapid deflection. The volume of iodine solution used in this titration is the measure of the iodine consumption of the sample. This volume of solution II divided by the sample weight gives the iodine consumption per

gram of sample. This equivalent multiplied by the weight of the sample used in an actual water titration will give the amount of solution II which should be subtracted from the buret reading during the titration for water.

Titration of the Unknown Sample

Thoroughly shake the unknown liquor sample, transfer a small portion of that liquor into a bottle stoppered with a medicine dropper, and weigh the dropping bottle and contents accurately. Add 20 ml. of solution I to the clean dry titration jar, titrate to the end point with solution II, and record the volume of solution II used. Transfer the desired portion of liquor from the bottle to the titration assembly and mixture mentioned above. Reweigh the dropping bottle accurately and obtain the sample weight by the difference between the first and second weights. Proceed with the titration of the unknown solution by the addition of solution II from the buret to the electrometric end point.

The volume of solution II needed for the second titration represents the sum of the volume needed for the water in the sample plus the volume needed for the iodine consumption of the sample. Obtain the volume consumed by the water by subtracting from this total volume a calculated volume of solution II equivalent to the iodine consumption by side reactions as previously determined. The water content of the unknown liquor can be calculated by the following equation:

$$\frac{\text{Corrected ml. solution II} \times \text{Water equivalent of solution II} \times 100}{\text{Sample weight in grams}} = \%\ \text{water} \quad (4)$$

Modification for Concentrated Calcium-Base Liquors

If a concentrated calcium-base liquor is added to the titrating mixture mentioned above, the liquor will form a gummy mass which cannot be dissolved by the titrating mixture, and the water titration is unsatisfactory. The following modification prevents the formation of this mass: add 20 ml. of solution I, 20 ml. of glacial acetic acid, and 20 ml. of absolute methanol to the titration bottle, titrate to the end point, and add the sample. Turn the stirring motor on immediately and proceed with the titration in the usual manner. The sample will be completely suspended or dissolved in the presence of the acetic acid, and the titration can be easily completed. The iodine-consumption corrective titration is carried out in 20 ml. of acetic acid and 40 ml. of absolute methanol.

Modification for Concentrated Semichemical Liquors

If a semichemical process liquor of more than 50% solids content is added to the titrating mixture mentioned above, the liquor will form a gummy mass similar to that formed by a concentrated calcium-base liquor. The following modification is necessary: dehydrate C.P. glycerine by heating in a beaker until rapid boiling occurs and allow to boil for 10 min. Pour into an Erlenmeyer flask stoppered with a tin-foil covered rubber stopper and allow to cool. Add 15 ml. of this glycerine, 15 ml. absolute methanol, and 25 ml. solution I to the titrating bottle, titrate to the end point, and add the sample. Turn on the stirring motor immediately and stir until the sample is in solution, and proceed with the titration in the usual manner. The iodine-consumption titration is carried out in 15 ml. of glycerine and 40 ml. of anhydrous methanol.

SUMMARY AND CONCLUSIONS

The method gives accurate values for the true water content and, by difference, total nonaqueous constituents in all types of residual pulping liquors. Comparison of results obtained by this method and the oven-drying procedures shows differences which are directly attributable to the amount of volatile constituents lost on the one hand and water retained by the various liquors during oven drying on the other. Reliability of the method has been proved both by the recovery of water added to residual liquors of known water content and by recovery of additional moisture from the residue obtained from oven-drying procedures on concentrated liquors. The method has been satisfactorily applied to all available types of residual pulping liquors. Corrections have been found possible for all substances present in the liquor that could interfere with the determination of moisture by this method, thereby giving a true value for water content.

Standard, readily available laboratory equipment is used, and the apparatus can be made completely portable. The method can be used by nontechnical personnel after a short training period. Results of analyses can be made available for operating personnel within 20 min. in contrast to the many hours' delay required by routine oven-drying methods. No special precautions are needed to prepare or store reagents used in the titrations.

It is felt that the use of the method will demonstrate its advantages over oven-drying techniques in obtaining a more accurate evaluation of the water content of residual liquors, and that it be considered for daily use as a new analytical procedure for routine liquor analysis. In view of its reliability as a true measure of moisture, we suggest that this method be given consideration as the standard method for determining the moisture content of residual pulping liquors, including sulphate, semichemical, and all forms of sulphite liquors.

LITERATURE CITED

1. Phillips, J. H., *Tappi* 34, No. 10: 101A–110A (Oct., 1951).
2. Jones, A. G., *Analyst* 76: 5 (Jan., 1951).
3. Mitchell, J., Jr., *Anal. Chem.* 23: 1069–1075 (Aug., 1951).
4. Mitchell, J., Jr., Kangas, L. R., and Seaman, W., *Anal. Chem.* 22: 484–485 (March, 1950).
5. Johannson, A., *Svensk Papperstidn.* 50, No. 11B: 124–126 (1947).
6. Johannson, A., *Acta Chem. Scand.* 3: 1058 (1949).
7. Linch, A. L., *Anal. Chem.* 23: 293–296 (Feb., 1951).
8. Milberger, E. C., Uhrig, K., Becker, H. C., and Lewis, H., *Anal. Chem.* 21: 1193 (Oct., 1949).
9. Roberts, F. M., and Lewis, H., *Anal. Chem.* 21: 1553 (Dec., 1949).
10. Goff, W. H., Palmer, W. S., and Huhndorff, R. F., *Anal. Chem.* 20: 344 (1948).
11. TAPPI Standards, Tentative and Official Testing Methods, Recommended Practices, Specifications. Published by the Technical Association of the Pulp and Paper Industry, New York, N. Y.
12. Mitchell, J., Jr., and Smith, D. M., "Aquametry," pages 389–390, New York, N. Y., Interscience Publishers, Inc., 1948.
13. Seaman, W., McComas, W. H., and Allen, G. A., *Anal. Chem.* 21: 510–512 (1949).

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A Lignin-Carbohydrate Bond in Wood

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Evidence pro and con for a lignin-carbohydrate bond in wood is reviewed. When attempts were made at the Forest Products Laboratory to fractionate wood into carbohydrate and lignin by grinding and sifting, lignin was concentrated in the very fine powder, but all fractions contained substantial quantities of lignin. Wood of maple, aspen, and spruce was treated with methanol and hydrochloric acid under conditions similar to those used to study the reactive chemical groups in native and purified cellulose. A large part of the hemicellulose dissolved. About 70% of the lignin in the hardwoods and 24% in the spruce dissolved in 20 volumes of methanol in 48 hr. Treatment of wood with a 17½% solution of alkali dissolved the hemicellulose of wood and made about 70% of the lignin in the hardwoods and about 30% of the lignin in the spruce soluble in methanol after removal and neutralization of the alkali.

THE question of a bond between lignin and the carbohydrate constituents of wood is continually recurring. It is a question of extreme importance to the pulp producer interested in higher pulp yields and to the research man seeking to obtain wood constituents in unaltered form. If the lignin and carbohydrates of wood are a physical mixture and removal of lignin is masked by the carbohydrates, present chemical pulping methods and procedures for isolating lignin and wood carbohydrates are too drastic. Methods for overcoming the masking action should be sought. If a chemical bond exists between the lignin and the carbohydrates, more specifically, less drastic means of cleaving that bond should be sought.

Many arguments for and against a chemical bond between the lignin and carbohydrates of wood have been advanced, but each thus far has failed to prove its case conclusively. A summary of many of these presentations was given by Brauns (*8*). The outstanding evidence for and against a lignin-carbohydrate bond will be reviewed in this paper. In addition, recent experiments at the Forest Products Laboratory to obtain further information on the existence of such a bond will be described.

ARGUMENTS AGAINST A LIGNIN-CARBOHYDRATE BOND

Perhaps the foremost argument against a chemical bond between the cellulose and lignin of wood is the physical structure of the wood cells. In the cells lignin is concentrated largely in the middle lamella; cellulose is in the cell walls and is associated with only small amounts of lignin. A dissection of the middle lamella, however, shows that large amounts of carbohydrate are associated with lignin in the middle lamella and may be combined with the lignin.

The crystalline structure of wood cellulose is also given as evidence against a chemical bond of cellulose to lignin because the x-ray pictures (*26*) obtained are those of pure cellulose. Crystalline cellulose, however, represents only about 46% of wood; total carbohydrate is 65 to 75% of wood. The x-ray pattern of the crystalline cellulose is so strong that it shows through weak patterns shown by other constituents of wood.

The solubility of a small amount of low-molecular-weight lignin (*4, 5, 7, 14, 20*) in organic solvents and water has been offered as evidence that some lignin exists in a free state.

Attempts to extract more lignin from wood by first grinding the wood for several days in a ball mill in order to break up the cells and overcome the enveloping action of the cellulose were unsuccessful (*6*). Nord and his co-workers (*10, 22, 30*) believe that the failure to extract more lignin is due to the masking action of carbohydrates.

If the carbohydrates are removed by "rot" organisms, more lignin can be extracted. Hydrolytic enzymes are usually associated with such organisms and may hydrolyze lignin-carbohydrate bonds. Attempts to produce a lignin free of carbohydrates by the action of rot organisms have not been successful. Harris (*17*) found that wood extracted before any of the hydrolytic enzymes present in it had a chance to act gave very little soluble lignin, but wood allowed to season in the usual manner yielded 1.8 to 3.1% of the wood as soluble lignin.

Schuerch (*31*) holds that the failure of lignin to dissolve is due to the poor solvent action of the solvents used and recommends solvents whose "hydrogen bonding" capacity is high. In mixtures of solvents he dissolved as much as 77% of the lignin. The reaction was in the presence of hydrogen chloride, and hydrolysis must have been involved. The possibility of hydrolysis has not been eliminated in any isolation of free lignin.

Bailey (*2*) digested aspen and jack pine wood in butanol-water mixtures that were buffered to prevent the formation of hydrogen ions that would cause hydrolysis. Eighty per cent of the lignin was removed, and Bailey concluded that there was no bond between lignin and carbohydrate in wood. It has been shown, however, that digestion in water (*1*) or in salt mixtures does cause hydrolysis of wood carbohydrates.

It is argued that some of the conditions used to separate lignin from carbohydrates are so mild that they could not cleave a glucosidic linkage.

ARGUMENTS FOR A LIGNIN-CARBOHYDRATE BOND

The insolubility of wood cellulose in cellulose solvents is evidence in favor of a chemical bond between lignin and the cellulose. Erdmann (*11*) found that cellulose in wood did not dissolve in cuprammonium solution and concluded that cellulose was chemically bound in wood. This conclusion was supported by Cross and Bevan (*9*), who found that the small amount of wood

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dissolved contained carbohydrate and lignin in the same composition as in the original wood. Hilpert (*18*) found that cuprammonium solution was not an inert solvent, because if allowed to react with wood for long periods of time, it dissolved about 80% of the wood. Both the residue and the material recovered from the extract contained nitrogen from the cuprammonium solution.

If wood is alternately hydrolyzed by dilute acid and extracted with cuprammonium solution, cellulose can be readily extracted. Freudenberg and his co-workers (*12, 13*) developed a method for isolating lignin based on this procedure. The need for treatment with dilute acid to free the cellulose is evidence for a bond. If the insolubility of the cellulose was due to an encrusting layer of lignin over the cellulose, grinding of the wood so as to break up the cells should overcome the protective action of the lignin. Staudinger and his co-workers (*32*) found that the solubility of wood in cuprammonium solution increased from 3.6% to 30 to 50% when ground in a ball mill for periods up to 40 hr. It is now believed that the increase in solubility may have been due to the cleavage of bonds of sensitive linkages by the heat generated in the ball mill. Levy and Jahn (*21*) found that the solubility of white pine groundwood increased from 15 to 27% when subjected to the hydrolyzing action of grinding in water. Grinding in alkali increased the solubility to 32%.

Cellulose and other wood carbohydrates in their free state may be fermented (*23*), but wood itself ferments very little. Pulping processes (*35*) increase the ease of fermentation of wood, and the greater the amount of delignification, the greater the amount of fermentation. Fine grinding of wood, according to Virtanen (*33, 34*) increases the ease with which wood carbohydrate is fermented by thermophilic organisms. Dilute-acid hydrolysis of wood (*15, 16*) has the same effect. On the basis of his work on grinding of wood, Virtanen concluded that part of the carbohydrates in wood are bound with lignin, and part are free. It is possible, however, that internal heat generated during the mechanical grinding may have cleaved sensitive linkages.

Lignin-carbohydrate complexes that show all tests of being definite compounds have been isolated. Kawamura and Higuchi (*19*) isolated a dioxane-soluble lignin-carbohydrate complex that was carefully purified and then methylated. On hydrolysis this product gave trimethyl xylose and methylated lignin. Digestion of the complex with takadiastase gave xylose.

The properties of lignin change with respect to color reactions, reactions to sulphite pulping liquor, yield of vanillin, and degree of unsaturation on isolation by all methods except alcohol solubility and some biological methods. This behavior leads to the conclusion that lignin in wood is bound to carbohydrates and because of that bond has a configuration that undergoes rearrangement when isolated from the carbohydrate.

EXPERIMENTAL

Several experiments were carried out by the author to obtain further information for or against the existence of a lignin-carbohydrate bond in wood.

Grinding of Wood

Microscopic examination of finely ground wood showed that substances in the middle lamella of the wood cell break more readily than the cell walls. On the basis of this observation it was concluded that it might be possible to fractionate the carbohydrate and lignin components of wood. White ash wood from sound trees was ground in a Wiley mill, and the dust obtained was carefully sifted through a vibrating screen. Lignin analyses were made of the whole sample and the various fractions. Table I shows that the finer particles contained the most lignin.

Table I. Lignin Content of Fractions of Dust Obtained by Screening Ground White Ashwood

		Lignin content			
Sample	*Total wood, %*	*Fraction retained on 40-mesh screen (38%), %*	*40 to 80-mesh fraction (51%), %*	*80 to 120-mesh fraction (5%), %*	*Fraction passing through 120-mesh screen (6%), %*
9D6	27.0	25.7	27.2	28.2	30.1
78A3	27.3	27.0	27.1	28.2	29.6
10A10	26.6	26.3	26.4	26.7	28.1

Regrinding of the combined fractions that passed through an 80-mesh screen, and fractionating, gave fractions with the lignin contents shown in the following tabulation:

Fraction	*Lignin content, %*
Retained on 120-mesh screen	27.2
120 to 200-mesh	30.3
Retained on bolting cloth	32.2
Through bolting cloth	38.1

Extraction of each of the fractions listed in Table I and the tabulation with 20 volumes of methanol yielded alcohol-soluble lignin ranging from 2.2% of the wood in the sample retained on a 40-mesh screen to 4.0% of the sample passing through bolting cloth.

It was concluded that the concentration of lignin in the very fine sample was due to the greater ease of breakage of the constituents of the middle lamella, which contains most of the lignin. The higher amounts of alcohol-soluble lignin from the fine sample were due to the larger amounts of lignin in the sample. It is evident that all parts of the cell are not bound in the same type of complex, because grinding breaks wood into particles containing different amounts of lignin.

Alcoholysis of Wood

Treatment of cellulose with methanol containing 1.8% of hydrogen chloride was used by Reeves, Mazzeno, and Hoffpauir (*27*) to determine reactive chemical groups. Even at 15 and 30°C., fluidity increased and introduction of methoxyl groups took place rapidly in the beginning of the treatment. The rate of change was more rapid than if glucosidic groups were involved. Similar experiments were carried out on cellulose acetate (*3*) using 2-methoxyethanol containing 0.15 *N* *p*-toluenesulphonic acid at 100°C. A very rapid alcoholysis occurred in the first 8 hr. of treatment, after which little change occurred.

The conditions used in the methanolysis of cellulose are similar to those employed when methanol lignin is isolated from wood. The treatment of wood with methanol and hydrochloric acid was therefore repeated

to determine the extent of the reaction on the total wood as measured in insoluble residue as well as the yield of lignin. Schuerch contended that the extent of the reaction was a matter of solubility of the lignin. In order to overcome this solubility factor, varying amounts of methanol were used.

Wood of maple, aspen, and spruce was cut to pass a 60-mesh screen and extracted first with ether and then with methanol to remove extractives and methanol-soluble lignin. Samples (100 grams dry basis) of each wood were placed in flasks with 300, 500, 1000, and 2000 ml. of methanol containing 2% of hydrogen chloride and heated under reflux for 48 hr. Table II shows the yields of the various products.

Table II. Yield of Products by Treatment of Wood with (90%) Methanol Containing 2% of Hydrochloric Acid[a]

Wood used	Lignin content, %	Ratio of methanol to wood	Residue[b]		Lignin recovered		Soluble loss, %
			Yield,[b] %	Lignin content,[c]	Yield,[b] %	Methoxyl content,[d] %	
Maple	21.1	3:1	69.0	21.3	6.0	25.3	25.0
Maple	21.1	5:1	63.0	15.5	11.1	25.3	25.9
Maple	21.1	10:1	61.0	13.6	12.7	25.4	26.3
Maple	21.1	20:1	58.0	9.8	15.4	25.4	26.6
Aspen	18.1	5:1	81.5	15.1	5.4	25.6	13.1
Aspen	18.1	10:1	76.7	12.4	8.2	25.5	15.1
Aspen	18.1	20:1	71.3	8.7	12.8	25.5	15.9
Spruce	26.8	5:1	75.0	25.5	2.65	21.5	22.3
Spruce	..	10:1	73.0	25.9	4.25	21.5	22.7
Spruce	..	20:1	69.0	26.0	6.70	21.4	24.3

[a] Time of treatment, 48 hr.
[b] Yields of residue and recovered lignin are calculated on extracted dried wood.
[c] Lignin content was calculated on residue.
[d] Methoxyl content was calculated on lignin recovered.

A relatively large fraction of the wood was dissolved during the heating period, indicating methanolysis and solution of the less stable portion of the wood. With increased amounts of methanol, more lignin dissolved, but there was only a slight increase in the carbohydrate dissolved. After the reaction, the methanol solution was neutralized with sodium bicarbonate, filtered, and concentrated to 150 ml. at 30 to 35°C., and poured into a large volume of water with vigorous stirring. The precipitate was filtered off, air dried, taken up again in methanol, and reprecipitated in water. The precipitate in each case was creamy white after drying in a vacuum oven.

Examination of the water solution from the precipitation of the lignin showed that it contained small amounts of substances that give the Maule reaction for lignin and a small amount of reducing sugar. Concentration of the water under vacuum gave a yellow dextrine-like syrup. The extent of loss of carbohydrates of the wood indicated that extensive hydrolysis had occurred. The greater extraction of lignin with increased amounts of methanol showed that extraction depended on solubility or peptization. The lignin was methylated during the process of isolation. As in the methanolysis of cellulose, bonds are cleaved under conditions that would not cleave glucosidic linkages.

EFFECT OF ALKALI PRETREATMENT ON LIGNIN SOLUBILITY IN WOOD

In a method for the isolation of hemicellulose directly from maple wood (*28*), treatment of wood with a 17½% solution of sodium hydroxide at room temperature followed by dilution to an alkali concentration of 3% extracted a large part of the hemicellulose without dissolving lignin.

If it is assumed that a chemical bond exists between hemicellulose and lignin in wood, and if that linkage were an ester of a lignin pseudo acid with an alcohol group of the carbohydrate or an ester of uronic acid with a hydroxyl group in lignin, it may be expected that it would cleave readily by the action of alkali. As a result of the cleavage, the sodium salt of the pseudo acid or of the phenolic group of lignin would be formed. Since this salt, because of its high molecular weight and the salting-out action of the alkali, would be insoluble, extraction of the hemicellulose without the lignin would be possible. A soluble lignin might also be produced.

To determine if soluble lignin is produced by the action of cold 17½% alkali on wood, maple, aspen, and sprucewood samples were cut to pass a 40-mesh screen and extracted with ethyl ether and then with methanol to remove extractives and soluble lignin. Samples (100 g.) of the extracted wood were treated with 2 to 3 parts of 17½% sodium hydroxide, mixed, and allowed to stand overnight at room temperature. The solutions of the samples were diluted to produce an alkali concentration of 6% and filtered in the absence of air through a fritted glass filter to remove alkali. The insoluble residues were washed with a 3% solution of alkali until there was no evidence of precipitable hemicellulose being removed. They were then suspended in methanol, and the residual alkali was neutralized with

Table III. Yield of Products by Treatment of Wood with 17½% Aqueous Alkali, Followed by Extraction with Methanol[a]

Wood	Original lignin content of wood, %	Alkali treatment		Methanol treatment		Residue		Lignin accounted for, %
		Total extractives, %	Hemicellulose recovered, %	Lignin recovered, %	Methoxyl content of lignin,[b] %	Yield, %	Lignin content,[c] %	
Maple	21.2	31	17.0	16.0	20.5	48	10.0	98.0
Aspen	18.1	20	14.1	14.7	20.6	56	5.0	96.6
Spruce	26.8	16	12.6	8.0	16.9	72	19.1	81.5

[a] Percentages based on wood unless otherwise noted.
[b] Methoxyl content calculated on the lignin recovered.
[c] Lignin content calculated on residue.

hydrochloric acid. The residue was extracted with methanol under reflux four times for periods of 4 hr. each. Table III shows the yield of products from the treatment.

About 70% of the lignin from the hardwoods and 24% from the spruce was recovered as soluble lignin. This lignin was not methylated during the process of isolation as was the case when lignin was isolated by acidic methanolysis of wood. The product was readily soluble in methanol and dioxane and light in color. Lignin accounted for in the case of hardwoods was almost quantitative. It is believed that this is evidence for a lignin-carbohydrate bond that is cleaved by the action of alkali.

DISCUSSION

The heterogeneity of the structure of the wood cells, the crystalline patterns of some of the wood cellulose, and the partial digestibility of wood cellulose by microorganisms indicate that a part of the cellulose in wood must be free and not combined with lignin. On the other hand, the following evidence favors the existence of a chemical bond between the lignin and carbohydrates of wood:

1. The insolubility of unhydrolyzed wood cellulose in cuprammonium solution and of lignin in lignin solvents except for a small amount of alcohol-soluble lignin that may have been freed from carbohydrates by naturally occurring hydrolytic enzymes in wood.
2. The failure to increase the alcohol solubility of lignin by grinding wood.
3. The unavailability of the hydroxyl groups of lignin in unhydrolyzed wood to methylation under conditions that would methylate isolated lignin.
4. The need for oxidizing or hydrolytic agents to free lignin for isolation.
5. The failure of cellulose in wood to undergo the xanthate reaction.
6. The change in properties of both wood carbohydrates and lignin after isolation by oxidizing or hydrolytic agents.
7. The isolation of chemically bound lignin-carbohydrate complexes.

Grinding of wood and separation into fractions with a higher concentration of lignin in the fines demonstrated the heterogeneity of wood and the friable nature of the middle lamella as observed previously by microscopic examination. It was not possible to separate a lignin-free cellulose fraction.

The cleavage of the lignin-carbohydrate bond by treatment with cold alkali or treatment with methanol-hydrogen chloride solutions, both of which are mild conditions compared to conditions required for normal glucosidic linkages, indicates a weak or sensitive linkage. Sakar and his co-workers (*29*) found evidence in jute fibers for a linkage between the carboxyl groups in the polyuronides of the hemicellulose and the hydroxyl groups of lignin because of the change in acid values on mild alkali treatment and the change in rate of delignification by chlorite treatment following alkali treatment.

Pew (*24, 25*) found color changes occurred when lignin in wood was treated with strong acid or acid in alcoholic solution that would indicate condensations or rearrangements in the lignin molecule due to the action of the acid. These changes may be due to cleavage of a lignin-carbohydrate bond that prevents them occurring in wood or to rearrangement or condensation promoted by the presence of acid ions, as appears to be the case in color changes of flavanones and chalcones that are promoted by acid ions.

The increase in solubility of lignin in organic solvents in the presence of acid or after treatment with acid may be due to the formation of polar compounds with increased solubility.

CONCLUSIONS

It may not be possible to prove conclusively that a chemical linkage exists between the lignin and carbohydrates of wood, but evidence certainly indicates the presence of such a bond. It is believed that the greatest progress in developing new methods for delignification and the isolation of wood constituents for research can come if a chemical bond is assumed and advantage is taken of alkaline or oxidizing pretreatments as an aid in the cleavage of a lignin-carbohydrate bond.

LITERATURE CITED

1. Aronovsky, S. I., and Gortner, R. A., *Ind. Eng. Chem.* 22: 264 (1930).
2. Bailey, A. J., *Paper Trade J.* 110, No. 1: 29 (1940).
3. Blair, M. G., *J. Am. Chem. Soc.* 74: 3411 (1952).
4. Brauns, F. E., *Paper Trade J.* 108, No. 1: 42 (1939).
5. Brauns, F. E., *J. Am. Chem. Soc.* 61: 2121 (1939).
6. Brauns, F. E., *Paper Trade J.* 111, No. 14: 33 (1940).
7. Brauns, F. E., *J. Org. Chem.* 10: 211 (1945).
8. Brauns, F. E., "Chemistry of Lignin," New York, 1952.
9. Cross, C. F., and Bevan, E. J., "Cellulose," London, 1910.
10. de Stevens, F., and Nord, F. F., *J. Am. Chem. Soc.* 74: 3326 (1952).
11. Erdmann, J., *Ann.* 138: 1 (1866).
12. Freudenberg, K., Harder, M., and Markert, L., *Ber.* 61B: 1760 (1928).
13. Freudenberg, K., Socher, H., and Durr, W., *Ber.* 62B: 1814 (1929).
14. Freudenberg, K., Janson, A., Knof, E., and Haag, A., *Ber.* 69B: 1415 (1936).
15. Hajny, G. J., Gardner, C. H., Ritter, G. J., and McCoy, E *J. Bacteriology* 56: 141 (1948).
16. Hajny, G. J., Gardner, C. H., and Ritter, G. J., *Ind. Eng. Chem.* 43: 1384 (1951).
17. Harris, E. E., *Ind. Eng. Chem.* 32: 1049 (1940).
18. Hilpert, R. S., and Woo, Q. S., *Ber.* 70B: 413 (1937).
19. Kawamura, I., and Higuchi, T., *J. Soc. Textile Cellulose Ind. (Japan)* 8: 335 (1952).
20. Klason, P., and Fagerlund, O., *Arkw. Kemi Mineral Geol.* 3, No. 6: 1 (1908).
21. Levy, J., and Jahn, E. C., *Paper Trade J.* 109, No. 23: 45 (1939).
22. Nord, F. F., and Schubert, W. J., *Holzforschung* 5, No. 1: 1 (1951).
23. Olson, F. R., Peterson, W. H., and Sherrard, E. C., *Ind. Eng. Chem.* 29: 1026 (1937).
24. Pew, J. C., *J. Am. Chem. Soc.* 73: 1678 (1951).
25. Pew, J. C., *J. Am. Chem. Soc.* 74: 2850 (1952).
26. Purvis, C. B., "Cellulose and Cellulose Derivatives," page 101, New York, 1943.
27. Reeves, R. E., Mazzeno, L. W., Jr., and Hoffpauir, C. L., *J. Am. Chem. Soc.* 72: 4773 (1950).
28. Rogers, S. C., Mitchell, R. L., and Ritter, G. J., *Anal. Chem.* 19: 1029 (1947).
29. Sakar, P. B., Chatterjee, H., Mazumdar, A. K., and Pal, K. B., *J. Textile Inst.* 39, No. 1: T 1–7 (1948).
30. Schubert, W. J., and Nord, F. F., *J. Am. Chem. Soc.* 72: 977 (1950).
31. Schuerch, C., *J. Am. Chem. Soc.* 74: 5061 (1952).
32. Staudinger, H., Dreher, E., and Ekenstam, A., *Ber.* 69B: 1099 (1936).
33. Virtanen, A. I., *Nature* 158: 796 (1946).
34. Virtanen, A. I., and Kikkela, O. E., *Suomen Kemistelehi* 11B: 30 (1938).
35. Virtanen, A. I., and Koistenen, O. A., *Svensk Kem. Tidskr.* 56: 391 (1944).

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Studies in Continuous Alkaline Pulping

III. The Pulping of Slash Pine

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Slash pine has been converted into chemical pulps of good yield by continuous methods. Concentration was maintained by the use of a very high liquor-wood ratio, 40:1. Chips were softened by presteaming 10 min. at 125 p.s.i. steam pressure and hammer-milled prior to pulping. Screened yields as high as 46.0%, based on original unsteamed wood, were attained in 15 to 20 min. cooking time. Pulping data for a wide range of liquor concentration—20 to 80 grams Na_2O per liter, and steam pressures, 115 to 170 p.s.i.g., are presented. Pentosan contents of pulps are lower than those found in conventionally cooked pulps. No relationship could be found between pentosan content and physical strength of pulps. Concentration of cooking liquor seems to effect physical strength, the strongest pulps being produced at the lowest concentrations. Pulps 95% as strong as the best commercial sulphate pulps have been produced in cooking times of less than 30 min. Using permanganate number as a measurement of bleachability, these pulps appear to have the same bleach requirements as conventionally cooked pulps of the same lignin content. Calculations of injections necessary for maintenance of concentration by fortification of cooking liquor with high-strength alkali are presented.

INVESTIGATIONS into high-speed continuous pulping thus far reported (*1*, *2*) indicate that high-purity chemical pulps of good yield can be produced in cooking times of 10 to 20 min. The factors which permit such high-speed pulping are constant cooking temperature, sustained liquor concentration during the cook, and expanded surface area of the chips before pulping. This expanded surface area is most important. The very high-speed reactions resulting from sustained liquor concentration at high temperature require large surface area of chips in order to accomplish uniform pulping and avoid low yields of pulp containing high percentages of screenings.

Under such conditions it was found possible to produce pulps from the pines or the hardwoods containing very high percentages of alpha-cellulose, 90.0 to 95.0% and very low percentages of lignin in cooking times as short as 15 min. The pentosan content of pulps cooked by these methods is controlled by the concentration of alkali in the cooking liquor. Concentrations as high as 80 g.p.l. will result in pulps as low as 2.0 to 3.0% pentosan while lower concentrations produce pulps of higher pentosan content. It was found that the process could be applied to the hardwoods, producing dissolving pulps of high alpha-cellulose and low pentosans, eliminating the acid prehydrolysis usually needed for such pulps.

This characteristic of the process for easy removal of hemicellulose, as measured by pentosan content, must be supressed in cooking the pines for the production of high-strength pulps. The first report on the process (*1*) showed that pine pulps cooked at a sustained concentration of 35 grams Na_2O per liter were 10 to 15% lower in tensile strength and 15 to 25% lower in bursting strength than pulps cooked under batch conditions in which the concentration was high (50 g.p.l.) at the start of the cook but decreased rapidly during the cook. These low-strength pulps were low in hemicellulose, containing only 2.9 to 3.4% pentosan, compared to a 7.5 to 8.0% pentosan content for the batch pulps.

The relationship between hemicellulose content and physical strength has been under investigation for several years and the literature contains many reports on the subject. R. E. March (*3*) prepared a holocellulose pulp by delignifying aspen with sodium chlorite and found it to be about 13% stronger in burst, 10% stronger in tensile, 24% weaker in tearing strength than a bleached kraft aspen pulp of about the same xylan content, 18.8%. This holocellulose pulp was then treated with alkali to produce pulps of different pentosan, or xylan content. He found that bursting strength showed a very sharp maximum at 13% xylan, a less pronounced maximum in tensile strength between 13 and 17% xylan, and a minimum in tear strength at a xylan content of 13 to 17%.

W. Galley (*4*) compared the strength developed or hydration of pulps to the behavior of plastic materials and plasticizers. He suggests that parts of the outer cell wall may be plasticized by water, permitting an intermolecular bonding. Cellulose, being crystalline in structure to a considerable extent, does not exhibit the plastic characteristics of a more amorphous material such as rubber. Water should be a compatible plasticizer, being highly polar as is the cellulose. Galley points out that pulps beaten in liquids of low polarity develop the same type of fibrillation as in hydration but the pulps do not exhibit any swelling tendency nor do they develop in strength with fibrillation alone. He attributes the development in strength to swelling or a plasticizing action between the water and the cell wall, developing a bond similar to two glued surfaces which are wet before pressed together. It might well be that the hemicelluloses, being amorphous in structure, are much more readily plasticized by water than is the crystalline cellulose.

L. G. Cottrall (*5*) points out the importance of hemicellulose in the strength development of pulps. He suggests that the hemicellulose may act as a plasticizing agent in the fiber, promoting swelling and fibrillation and suppressing the cross-fiber fragmentations found in beaten pulps of low-hemicellulose content. The hemicellulose acts in two conflicting ways in strength development. The hemicellulose is much shorter in

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chain length than the cellulose and is therefore lower in inherent strength. Acting as a bonding agent, however, it increases the bonding forces between fibers. Therefore, Cottrall points out that the per cent hemicellulose in the pulp should increase the strength of the sheet up to a certain point. Beyond this point, further increases in hemicellulose will decrease the inherent strength of the fiber mixture more than its bonding strength increase, with the net result of lower overall strength. The ideal hemicellulose content of pulps should be the percentage which gives the maximum bonding strength without excessive loss in intrinsic fiber strength.

It was planned, in the work described here, to fully explore the pulping characteristics of slash pine by rapid continuous methods with particular attention to the development of high-strength pulps. It was felt, in view of the importance placed on hemicellulose content of pulps for high strength, that efforts should be made to keep hemicellulose as high as possible after the characteristics of slash pine pulped under various concentrations of alkali had been evaluated.

The only method used in this laboratory for evaluating the quantity of hemicellulose in pulps has been the TAPPI standard method for determining pentosan, or xylan. This method is quite satisfactory for hardwood pulps since most of the hemicellulose is in the form of pentosans. The hemicelluloses in slash pine are made up about equally of pentosans and hexosans and, strictly speaking, the pulp should be analyzed for both xylan and mannan. However, the data of F. T. Ratliff (*6*) indicate that the ratio of mannan to xylan in the hemicellulose of bleached kraft pulps remains about the same as in the original wood. He found that the ratio of mannan to xylan in the original pine was 0.92:1.0 while this ratio for four bleached kraft pulps and one semichemical bleached kraft pulp was 1.1:1.0. It therefore seems safe to assume that pentosan analysis of kraft pulps is a measure of half the hemicellulose.

METHOD OF PROCEDURE AND PRESENTATION OF DATA

The plan of attack was laid out in the following manner. First, since it is advantageous to conserve pentosan in the pulp, the best conditions for presteaming the chips before hammer-milling must be found. It is known that, even though the presteaming liquors are kept slightly alkaline with Na_2CO_3, 35% or more of the total pentosan can be removed in this step. Therefore, it is necessary to find the optimum conditions of steam pressure and time which will give maximum yield and pentosan content of chips and still permit satisfactory surface expansion in the hammer mill.

Second, the pulping characteristics of the shredded chips over wide ranges of concentration, temperature, and cooking time must be determined. Yield and screening data and the effect of cooking conditions on lignin and pentosan content and permanganate numbers of resultant pulps must be determined. In this phase of the work concentration is maintained at a nearly constant value by the use of extremely high liquor ratios because the experimental equipment does not permit the use of liquor injections during the cook. The liquor ratio used was 40:1, corresponding to a per cent chemical of 80% at 20 g.p.l. and 320% at 80 g.p.l.

Third, the effect of per cent chemical on cooking time and analysis of pulps should be known. Therefore, at one fixed initial concentration, per cent chemical should be varied stepwise from the very high value corresponding to a liquor ratio of 40:1 down to a value approaching that used in commercial practice.

Fourth, some information should be obtained on the importance of chip size on the kinetics of the pulping reaction. Chips should be hammer-milled with and without presteaming. The hammer-milled products should be fractionated into different size ranges by screening and the pulping characteristics of each size range determined.

Fifth, pulps prepared over a wide range of cooking conditions, whose screening contents are reasonable, should be made into handsheets for physical strength evaluation. Strength characteristics of these pulps should be compared to the strength of one or more commercial type kraft pulps produced by batch methods.

Slash pine chips were obtained from the Hudson Pulp and Paper Co. at Palatka, Fla. These chips were taken from the chip conveyor between the chip screens and storage silos. Chips were rescreened on the laboratory shaking screen, using 1 in. and $^1/_4$-in. mesh screens. The fraction passing 1 in. and retained on $^1/_4$-in. screen was dried to approximately 8% moisture in the School of Forestry dry kiln and stored for further use.

Chips were presteamed in the laboratory digester using 2000 grams dry wood per charge and 10 liters of liquor containing 4.0 grams Na_2CO_3 per liter. Steam pressures of 125 to 170 p.s.i.g. were used at steaming times of 5 to 15 min. The steamed chips were hammer-milled in the laboratory hammer mill, using $^1/_2$-in. expanded metal as the discharge screen. It was found that exposure to 125 p.s.i. steam for 10 min. was sufficient for satisfactory hammer-milling.

Part of these hammer-milled chips were air dried for 48 hr. and screened on a Denver gyratory screen. The shredded chips were separated by this method into material held on 4-mesh screen, that which passed 4-mesh but was retained on 6-mesh, the fraction between 6 and 8-mesh, and the fines passing 8-mesh. The fines were discarded because earlier work had shown that they cause a reduction in tearing strength of the resultant pulps.

Another batch of dry chips was hammer-milled without presteaming. The milling and screening procedure duplicated the methods described for presteaming chips.

In the first series of cooks, steamed and hammer-milled chips were cooked under conditions of constant steam pressure and sustained concentration in pulping equipment previously described (*7*). The shredded wood was not separated into screen fractions before cooking, being used exactly as it came from the hammer mill. Chips contained about 55% moisture as charged to the digesters. Weight of wood charged was 300 grams moisture-free and 13.0 liters (80°F.) of liquor, corresponding to a liquor-wood ratio of 40:1, were used. Digesters had been brought to full cooking temperature before the wood was charged and liquor was heated to about 20 p.s.i. higher pressure than the cook before being metered into the digester.

Cooks were carried out at 20, 35, 50, and 80 g.p.l., expressed as Na_2O. Sulphidity was held constant at 25%. Cooking times varied from 5 to 90 min., de-

pending on the severity of the cooking conditions. Pulps were screened on a 10-cut, flat screen and total yield, screenings, and screened yield were evaluated. Samples of selected screened pulp were dried and analyzed by TAPPI standard method for lignin, pentosan, and permanganate number. In the determination of permanganate number, 50 ml. of 0.1 *N* permanganate

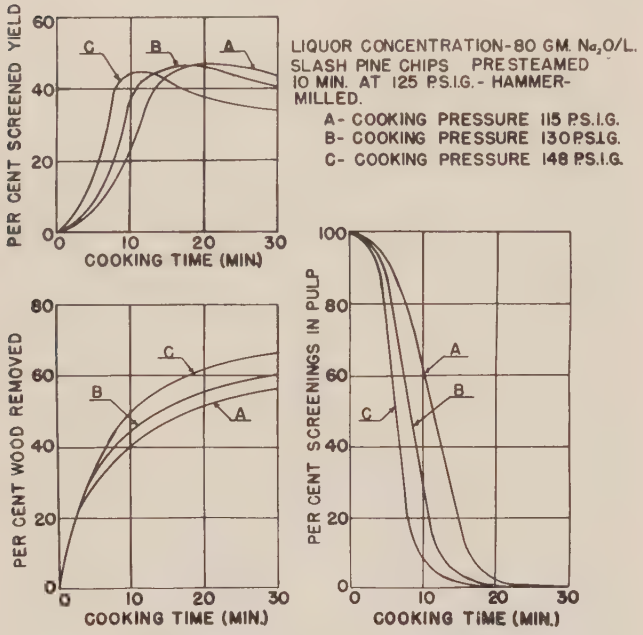
PER CENT SCREENED YIELD
COOKING TIME (MIN.)
LIQUOR CONCENTRATION-80 GM. Na2O/L.
SLASH PINE CHIPS PRESTEAMED
10 MIN. AT 125 P.S.I.G.- HAMMER-
MILLED.
A- COOKING PRESSURE 115 P.S.I.G.
B- COOKING PRESSURE 130 P.S.I.G.
C- COOKING PRESSURE 148 P.S.I.G.
PER CENT WOOD REMOVED
PER CENT SCREENINGS IN PULP

Fig. 1. Cooking curves, slash pine pulped at 80 g.p.l.

were used in all tests to avoid the change from 25 to 40 ml. required by the TAPPI method for hard pulps. All of the data for this series of cooks are presented in Table I. Typical cooking curves for the 80 and 20 g.p.l. cooks are shown in Figs. 1 and 2.

A cooking liquor of 35 g.p.l. and 25% sulphidity was used throughout the next series of cooks. Steam pressure was held constant at 170 p.s.i.g. Liquor ratio was varied so that per cent chemical could be studied. The percentages of chemical studied were 133, 72, 48, 34, and 23. Pulps were handled as in the preceding series. In this series, black liquor, sampled 2 min. before the end of the cook, was analyzed, using the TAPPI standard method which uses the evaluation of H_2S in the sulphide determination. From the analytical data, chemical consumption was calculated as grams Na_2O consumed per gram of wood dissolved. The calculated values for chemical consumption were averaged, throwing out those few values which, from their numerical value were obviously in error. A calculated concentration value was then computed for all cooks, using the observed yield and liquor ratio data and the average chemical consumption value. All of these data are listed in Table II. The cooking curves for this series are presented in Fig. 5.

The next series of cooks involved the study of chip size. Dry chips which had been hammer-milled without presteaming were separated into various sized screen fractions and each fraction was pulped separately. The screen fractions studied were +4 mesh, −4+6 mesh and −6+8 mesh. (It should be noted that the chips were sized according to cross section at right angles to the grain. The length of chip in the grain direction was practically the same for all screen fractions.) The cooking conditions employed were as follows: concentration, 40 grams Na_2O per liter; sulphidity, 25%; liquor-wood ratio, 40:1; cooking pressure, 148 p.s.i.g. For comparison, dry, mill-size chips and mill-size water-soaked chips were cooked under the same conditions as the sized chips. The cooking data are shown in Table IIIA and Fig. 3 shows the same data graphically.

Continuing this series, chips were presteamed for 10 min. at 125 p.s.i.g. before hammer-milling. The shredded chips were dried, separated into various screen fractions, and cooked in the same manner as the dry hammer-milled chips. These data are listed in Table IIIB and shown graphically in Fig. 4.

A large number of the pulps whose cooking data are listed in Table I were evaluated for physical strength. TAPPI standard methods were used throughout, with the exception that a Valley sheet mold was used for the formation of handsheets, resulting in a sheet diameter of $7^3/_4$ in. Tear, burst, and tensile strength values were calculated according to TAPPI Standard T 220 m. For comparison purposes, two pulps were prepared by batch methods and their physical strength values were determined. The first of these pulps was prepared under the following conditions: chips, dry, mill size; liquor concentration, 50 g.p.l.; sulphidity, 25%; per cent chemical, 18; liquor-wood ratio, 3.8; maximum steam pressure, 115 p.s.i.g.; time to maximum pressure, 60 min.; time at maximum pressure, 60 min. All cooking conditions for the second pulp were the same as for the first except that 165 min. were used to reach maximum pressure and the cook was held at maximum pressure for 70 min. The physical strength data for these two pulps and corresponding data for five pulps, selected as representative of those listed in Table I, are presented in Table IV. Figure 8 shows a comparison of the strength of pulps cooked at various sustained concentrations and constant pressure. A com-

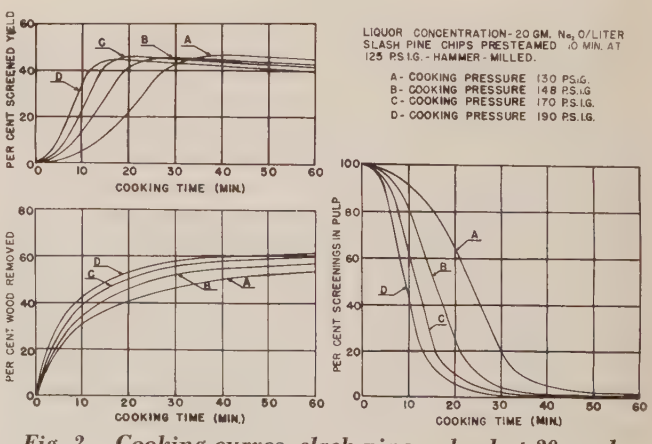
PER CENT SCREENED YIELD
COOKING TIME (MIN.)
LIQUOR CONCENTRATION-20 GM. Na2O/LITER
SLASH PINE CHIPS PRESTEAMED 10 MIN. AT
125 P.S.I.G.- HAMMER-MILLED.
A- COOKING PRESSURE 130 P.S.I.G.
B- COOKING PRESSURE 148 P.S.I.G.
C- COOKING PRESSURE 170 P.S.I.G.
D- COOKING PRESSURE 190 P.S.I.G.
PER CENT WOOD REMOVED
PER CENT SCREENINGS IN PULP

Fig. 2. Cooking curves, slash pine pulped at 20 g.p.l.

parison of the strength of batch type pulps to the 20 g.p.l. sustained concentration cooks is shown in Fig. 9.

The relationship between pentosan in pulps and concentration of cooking liquor is shown in Fig. 6. The solid line represents an average of all pentosan values at each concentration listed in Table I. The two dotted lines indicate the extremes of pentosan content which

Table I. Effect of Operating Variables on the Continuous Pulping of Slash Pine[a]

Cook No.	Liquor[b] conc., g.p.l.	Cooking pressure, p.s.i.g.	Cooking time, min.	Yield, % of steamed wood		Screenings, % of pulp	Analysis of pulp		
				Total	Screened		Lignin, %	Pentosan, %	Permanganate No.
637	20	130	7	71.8	5.4	92.4	...	...	..
638	20	130	13	65.2	9.6	85.4	...	...	..
639	20	130	20	60.0	21.9	63.5	18.9	5.4	...
640	20	130	30	54.0	43.0	20.4	14.7	5.4	39.4
687	20	130	60	45.4	44.6	1.6	8.1	4.6	31.0
688	20	130	90	42.2	42.0	0.3	...	...	...
627	20	150	7	65.2	7.0	90.0	...	...	...
628	20	150	13	61.0	22.1	64.2	...	...	...
629	20	150	20	55.2	41.2	24.0	14.6	4.7	...
630	20	150	30	47.6	45.4	4.6	9.2	4.4	...
682	20	150	50	43.8	43.2	1.6	6.1	4.1	26.6
631	20	150	60	43.5	43.1	0.9	4.0	3.9	...
683	20	150	80	40.6	40.6	0.0	...	4.1	...
481	20	170	10	60.6	22.9	61.6	...	...	...
482	20	170	15	53.6	41.7	22.2	...	...	...
591	20	170	17	51.8	45.2	12.6	...	3.9	...
524	20	170	20	50.8	44.5	11.8	8.9	4.0	34.2
592	20	170	23	47.6	45.7	4.1	...	3.6	...
567	20	170	27	44.5	43.2	3.2	...	3.6	...
608	20	190	5	68.6	9.8	85.8	...	...	...
609	20	190	10	57.4	33.6	41.5	...	...	...
610	20	190	15	49.1	43.8	14.0	11.0	4.8	...
611	20	190	20	47.2	44.2	6.2	7.4	4.5	...
612	20	190	30	43.2	42.6	1.4	3.8	3.6	...
652	35	115	7	69.5	5.5	92.2	...	...	...
653	35	115	15	61.7	15.6	75.6	...	...	...
654	35	115	21	56.6	34.2	39.4	16.2	4.8	...
655	35	115	30	51.1	46.8	8.0	12.5	4.0	37.7
656	35	115	60	43.8	43.8	0.0	...	3.3	20.9
642	35	130	7	68.6	6.2	90.9	...	...	...
643	35	130	15	56.6	32.9	44.2	17.3	4.6	...
203	35	130	20	52.1	47.7	8.7	12.3	3.6	...
644	35	130	30	47.5	47.0	1.2	8.0	4.2	29.9
645	35	148	5	70.0	6.7	90.4	...	...	...
646	35	148	10	59.5	29.0	50.6	18.0	3.9	...
156	35	148	15	53.2	48.3	8.7	12.8	3.0	...
157	35	148	20	49.4	48.4	2.0	8.5	3.0	...
647	35	148	30	45.0	44.8	0.4	4.7	3.2	20.0
648	35	170	5	66.8	13.2	80.3	...	...	...
649	35	170	10	55.4	43.9	20.7	13.4	4.1	...
480	35	170	15	46.8	45.2	3.3	7.0	3.6	29.7
650	35	170	20	44.9	44.2	1.6	...	...	...
651	35	170	30	41.2	41.1	0.2	2.6	2.5	11.9
669	50	115	7	68.6	4.3	93.6	...	...	...
670	50	115	15	58.7	21.4	63.4	...	...	...
671	50	115	20	54.2	36.4	32.8	14.9	3.7	39.9
672	50	115	30	48.2	46.1	3.4	9.2	3.1	32.8
673	50	115	60	41.9	41.9	0.0	2.7	2.9	...
657	50	130	7	66.0	9.0	86.5	...	...	...
158	50	130	10	59.6	17.0	70.4	...	...	...
658	50	130	15	54.4	40.0	26.3	14.9	3.7	...
659	50	130	20	48.6	45.5	6.6	9.4	3.3	33.8
660	50	130	30	44.9	44.2	1.4	5.4	2.5	22.6
661	50	130	60	40.0	40.0	0.0	...	...	...
413	50	148	5	64.8	7.2	88.8	...	...	...
414	50	148	10	53.1	43.4	17.8	14.3	2.5	41.0
415	50	148	15	47.3	45.6	3.4	10.9	2.3	41.0
416	50	148	20	43.8	43.5	0.4	4.6	1.7	25.8
417	50	148	30	40.7	40.6	0.1	...	...	...
426	50	148	60	36.2	36.2	0.0	...	...	...
674	50	170	5	62.4	21.8	65.0	...	...	...
675	50	170	12	45.4	41.2	9.4	6.9	2.3	26.9
676	50	170	20	41.4	40.7	1.6	3.0	2.1	15.0
677	50	170	30	36.0	36.0	0.0	...	1.8	...
678	50	170	60	33.4	33.4	0.0	...	...	...
689	80	115	5	69.6	6.0	91.6	...	...	...
690	80	115	10	59.4	23.1	61.1	...	...	...
691	80	115	15	52.4	43.6	16.8	14.4	3.2	40.3
692	80	115	20	47.2	46.4	2.0	9.5	2.6	33.3
693	80	115	30	43.6	43.4	0.2	...	...	...
694	80	130	5	68.5	8.5	87.5	...	...	...
695	80	130	10	51.8	37.7	27.2	15.0	3.5	40.8
696	80	130	15	47.6	45.7	3.9	10.7	2.7	36.8
697	80	130	20	46.1	45.8	0.6	...	...	...
698	80	130	30	40.5	40.5	0.0	...	...	...
699	80	148	5	62.3	17.4	72.0	...	...	...
700	80	148	10	48.8	44.6	8.7	11.6	3.3	37.2
701	80	148	15	42.6	42.0	1.2	5.4	1.6	23.4
702	80	148	20	37.4	37.3	0.2	...	...	...
703	80	148	30	33.8	33.8	0.0	...	..	..

[a] Chips steamed 10 min. at 125 p.s.i.g., shredded by hammer-milling. Yield of original chips 94.7%.
[b] Liquor-wood ratio 40:1. Sulphidity of 25% used throughout.

may be incurred by differences in either cooking time or steam pressure. Figure 7 shows the relationship between lignin content of pulps and their permanganate numbers.

DISCUSSION

Presteaming and Hammer-Milling

It was found that slash pine can be satisfactorily shredded in the hammer mill after steaming for 10 min. at steam pressures between 125 and 170 p.s.i.g. A

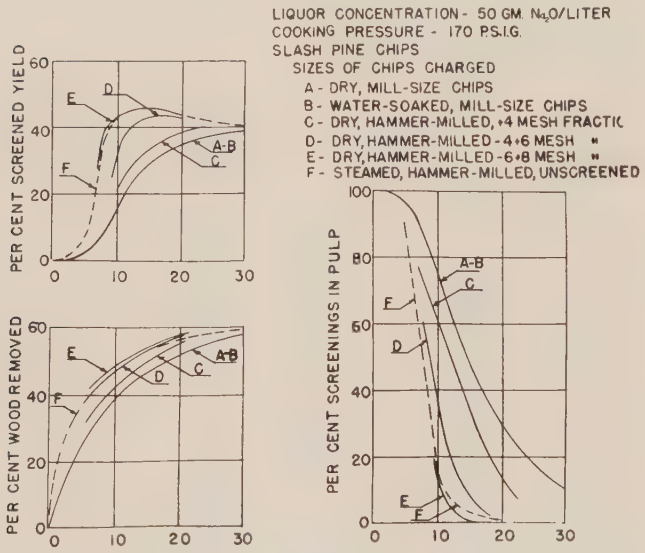
LIQUOR CONCENTRATION - 50 GM. Na_2O/LITER
COOKING PRESSURE - 170 P.S.I.G.
SLASH PINE CHIPS
SIZES OF CHIPS CHARGED
A - DRY, MILL-SIZE CHIPS
B - WATER-SOAKED, MILL-SIZE CHIPS
C - DRY, HAMMER-MILLED, +4 MESH FRACTIC
D - DRY, HAMMER-MILLED - 4+6 MESH "
E - DRY, HAMMER-MILLED - 6+8 MESH "
F - STEAMED, HAMMER-MILLED, UNSCREENED
PER CENT SCREENED YIELD
PER CENT WOOD REMOVED
PER CENT SCREENINGS IN PULP

Fig. 3. Effect of chip size in slash pine pulping chips reduced by dry hammer-milling

typical screen analysis of the shredded product, using $^1/_2$-in. expanded metal as the mill discharge screen, is approximately as follows.

Screen size, meshes per in.	+2	−2+3	−3+4	−4+8	−8+10	−10+16	−16
Wood retained, %.....	1.2	17.2	36.3	33.4	5.4	3.2	3.4

Steaming the chips for less than 10 min. does not permit softening into the chip centers, resulting in increased percentages above 4 mesh in the shredded product. Steaming for 15 min. or more does not improve the shredded product but causes unnecessary loss in yield and pentosan content. When steamed 10 min. at 170 p.s.i., 35% of the original pentosan is dissolved and total yield is 94.0% of the original dry wood. When the chips are steamed at 125 p.s.i., the total yield is 94.7% and 27.3% of the original pentosan is dissolved.

The possibility of increasing the pentosan content of the shredded chips by using Na_2SO_3 instead of Na_2CO_3 in the steaming solution was investigated. It was found that a molar ratio of 2 Na_2SO_3 to 1 Na_2CO_3, at a total concentration of 3.7 grams Na_2O per liter, resulted in the same yield and milling characteristics as when Na_2CO_3 alone was used. Pentosan removal was less, 20.9% of the pentosan being dissolved in 10 min. at 125 p.s.i., as compared to 27.3 for Na_2CO_3 under the same conditions. However, subsequent pulping experiments showed that this saving in pentosan in the chips did not result in increased pentosan content in the pulps.

Presteaming conditions for all of the pulping experiments reported in this paper were 10 min. exposure to 125 p.s.i. steam pressure in a solution containing 4.0 grams Na_2CO_3 per liter.

Power requirements for shredding the steamed chips in a size 1 Gruendler hammer mill were estimated. It was found, at a feed rate of 738 lb. per hr., that power consumption was 4.3 kw.-hr. per ton of dry wood.

All yield data, unless otherwise specified, are based on wood charged to the digester. When presteamed wood is used, wood charged to the digester is 95% of the original dry chips.

Effect of the Cooking Variables on the Rate of Pulping

The effects of concentration, temperature, and time are shown in Table I and Figs. 1 and 2. It is apparent that for each concentration studied, there is an optimum operating range of steam pressures, or temperatures. At 20 g.p.l. the best range appears to be 150 to 170 p.s.i.g.; at 35 g.p.l. the range is 130 to 148 p.s.i.g.; at 50 g.p.l. a steam pressure of 115 to 148 appears to give best results, while at 80 g.p.l., pressures of 115 to 130 p.s.i. are best suited. Beyond these pressures, the reaction rate increases but screened yield is reduced. Maximum screened yield is the criterion used in determining optimum conditions. The screened yield curves of Figs. 1 and 2 show that for every set of conditions of concentration and steam pressure there is an optimum cooking time at which maximum screened yield is obtained. The milder the cooking conditions, the broader will be this time range.

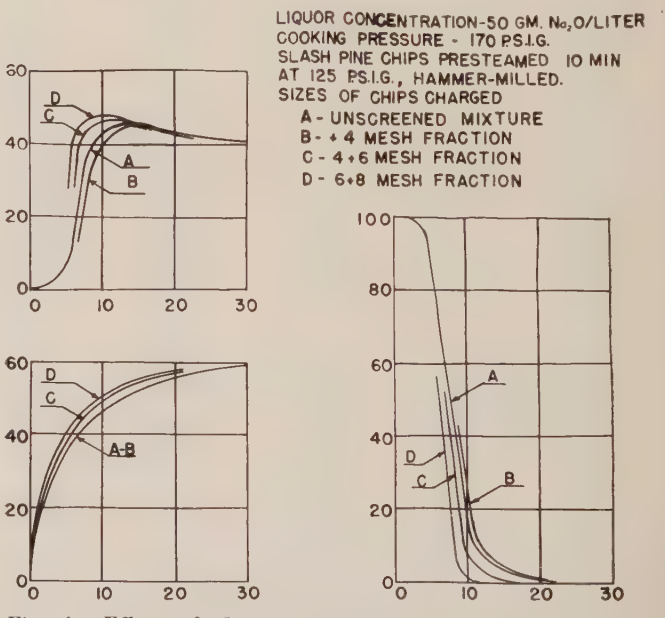
LIQUOR CONCENTRATION-50 GM. Na_2O/LITER
COOKING PRESSURE - 170 P.S.I.G.
SLASH PINE CHIPS PRESTEAMED 10 MIN
AT 125 P.S.I.G., HAMMER-MILLED.
SIZES OF CHIPS CHARGED
A - UNSCREENED MIXTURE
B - + 4 MESH FRACTION
C - 4+6 MESH FRACTION
D - 6+8 MESH FRACTION

Fig. 4. Effect of chip size in slash pine pulping chips reduced by presteaming and hammer-milling

Theoretically, it would seem that for any set of cooking conditions a single specific cooking time should give maximum yield of screening pulp. The data show that slash pine can be converted to pulp by rapid continuous methods with a screened yield as high as 48.3% on an oven-dry basis (cook nos. 156–157), which is 1 to 5% higher than is usually attained in commercial practice.

At first glance, the yield and screening data indicate that there might be considerable degradation in converting screening into pulp. For example, in cooking

at 20 g.p.l. and 130 p.s.i. steam pressure two successive cooks show the following yield data:

Cook no. 640—Total yield = 54.0%; screened yield = 43.0%; screenings = 20.4%
Cook no. 687—Total yield = 45.2%; screened yield = 44.6%; screenings = 1.6%

Under these mild cooking conditions, the two examples are 30 min. apart in cooking time, the first being carried out in 30 min. During this 30-min. interval, screened yield increased only 1.6% while total yield was decreasing 8.8%. However, when one considers lignin removal from the pulp, degradation is not as great as loss in yield indicates. If it can be assumed that screenings contain 20% lignin, the total lignin, based on 100 grams dry wood, in cook no. 640 is

$$43.0 \times 0.147 + 54.0 \times 0.204 \times 0.20 = 6.3 + 0.22 = 6.52 \text{ grams}$$

The lignin in cook no. 687 is

$$44.6 \times 0.081 + 45.4 \times 0.016 \times 0.20 = 3.6 + 0.14 = 3.74 \text{ grams}$$

The lignin removed in the 30-min. interval is

$$6.52 - 3.74 = 2.78 \text{ grams or } \frac{2.78 \times 100}{54.0 - 45.4} = 32.3\% \text{ of yield loss}$$

Thus, 100.0−32.3 or 67.7% of the yield loss is due to degradation rather than lignin removal.

A similar analysis of the most drastic cooking conditions, 80 g.p.l. and 148 p.s.i. steam pressure, shows that there is less degradation under these conditions than when the wood is cooked at 20 g.p.l. and 130 p.s.i. steam pressure. Calculations show that 45.2% of the yield loss is due to lignin removal and 54.8% of cellulosic material is due to dissolution. Cooks used for this calculation were nos. 700 and 701.

The best cooks, from a screened yield standpoint, nos. 156 and 157, should show the least degradation. Here the lignin removal was calculated to be 67.2% of the loss in yield, the remaining 32.8% being loss of purified pulp. Losses other than lignin in all these cases must be either hemicellulose or cellulose, since all other solubles must have been removed early in the cook.

The data indicate that further refinements in the surface area development prior to cooking should pay off with increased screened yields. An earlier publication on the process (*8*) showed that the maximum screened yield that could be attained when full-size chips were cooked at 50 g.p.l. sustained concentration and 148 p.s.i. constant steam pressure was 38.8%. When wood was presteamed and hammer-milled under the same conditions before cooking, this yield was increased to 42.4%, based on original unsteamed wood. If mechanical pretreatment can be improved so that all material has a cross section of 4 to 8 mesh, a large part of the carbohydrate loss should be avoided. At present the wood charged to the digester contains 54.7% of material over 4 mesh, of which 18.4% is over 3 mesh. On the other hand, 12.0% of the wood is under 8 mesh in cross section. It seems obvious that the undersized material must be degraded while a large part of the oversize is still in screening form. Reduction in screenings

Table II. Effect of Per Cent Alkali on the Continuous Pulping of Slash Pine

Cook No.	Alkali, g. Na_2O per 100 g. wood, %	Steam pressure, p.s.i.g.	Cooking time, min.	Final liquor conc., g.p.l. (titd.)	Chem.[a] consumption, g. Na_2O per g. wood	Final liquor conc., g.p.l. (calcd.)	Total yield, % of orig. wood	Screenings, % of total yield	Screened yield, % of orig. wood	Analysis of pulp: Lignin, %	Analysis of pulp: Pentosan, %	Analysis of pulp: Permanganate No.
...	133	170	0	35.0	...	35.0	100.0	100.0	0.0	27.5	9.1	...
648	133	170	5	...	...	31.9	66.8	80.3	13.2	...	...	...
649	133	170	10	...	...	31.2	55.4	20.7	43.9	13.4	4.1	...
480	133	170	15	...	...	30.6	46.8	3.3	45.2	7.0	3.6	29.7
650	133	170	20	...	...	30.5	44.9	1.6	44.2	...	...	...
651	133	170	30	...	...	30.3	41.2	0.2	41.1	2.6	2.5	11.9
...	72	170	0	35.8	...	35.8	100.0	100.0	0.0	27.5	9.1	...
704	72	170	5	...	...	30.1	67.4	81.8	12.4	...	...	...
705	72	170	12	...	...	28.4	52.6	15.4	44.5	11.6	3.8	37.0
706	72	170	18	...	...	27.7	46.7	4.2	44.8	7.1	3.4	28.2
707	72	170	30	...	...	27.2	42.0	0.2	41.8	2.7	3.2	13.6
708	72	170	60	...	...	26.6	37.2	0.2	37.2	...	...	...
...	48	170	0	35.4	...	35.4	100.0	100.0	0.0	27.5	9.1	...
709	48	170	5	...	...	28.1	71.0	90.0	7.0	...	...	...
710	48	170	12	26.3	0.219	25.4	55.2	25.6	41.0	13.6	4.4	...
711	48	170	18	25.7	0.205	24.2	48.0	5.6	44.4	7.6	3.8	29.4
712	48	170	30	24.1	0.232	23.5	43.8	0.6	43.5	3.3	3.6	16.3
713	48	170	60	21.9	0.262	22.6	38.2	0.0	38.2	...	...	...
...	47	170	0	35.6	...	35.6	100.0	100.0	0.0	27.5	9.1	...
714	47	170	10	...	...	26.0	60.2	56.4	26.2	...	...	...
715	47	170	20	24.9	0.214	23.7	47.0	6.3	44.0	7.6	4.2	29.6
716	47	170	30	23.3	0.241	23.1	43.2	1.0	42.8	3.3	3.8	16.7
717	47	170	60	22.0	0.257	22.4	39.2	0.0	39.2	1.6	...	9.4
718	47	170	90	21.0	0.273	22.1	37.7	0.0	37.7	...	...	...
...	34	170	0	35.3	...	35.3	100.0	100.0	0.0	27.5	9.1	...
719	34	170	10	...	...	22.7	59.9	64.8	21.4	...	...	...
720	34	170	20	20.8	0.233	20.2	49.3	9.4	44.7	7.8	4.8	29.6
721	34	170	30	16.4	0.310	19.2	44.8	2.3	43.9	4.1	4.6	19.9
722	34	170	60	17.5	0.255	18.0	39.4	0.0	39.4	...	...	...
723	34	170	90	15.8	0.288	17.7	38.3	0.0	38.3	...	...	...
...	23	170	0	35.4	...	35.4	100.0	100.0	0.0	27.5	9.1	...
724	23	170	10	16.5	0.304	19.2	64.4	79.8	13.0	...	...	...
725	23	170	20	15.2	0.248	15.4	52.6	16.9	43.9	...	...	...
726	23	170	30	11.3	0.290	13.9	49.2	4.8	45.8	8.7	5.5	32.8
727	23	170	60	11.3	0.259	12.3	43.0	0.0	43.0	2.8	5.7	14.3
728	23	170	90	10.2	0.266	12.1	42.4	0.0	42.4	...	...	...

[a] Cooks 721, 724, 726 not used in computing average value of grams Na_2O consumed per gram wood dissolved. Average value of all others = 0.246 g. Na_2O/g. wood dissolved.

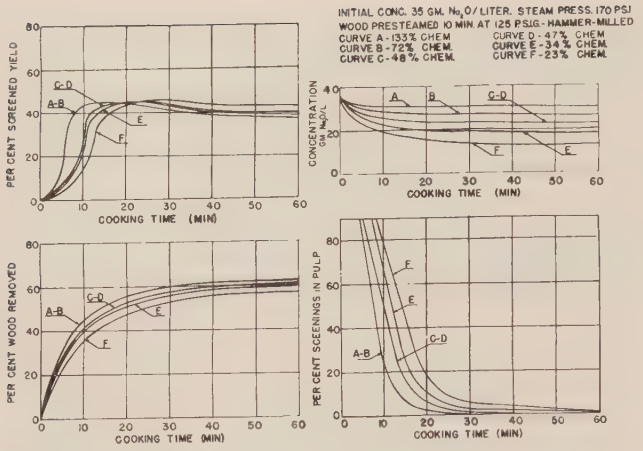
INITIAL CONC. 35 GM. Na_2O/LITER. STEAM PRESS. 170 PSI
WOOD PRESTEAMED 10 MIN. AT 125 P.S.I.G.- HAMMER-MILLED
CURVE A - 133% CHEM.
CURVE B - 72% CHEM.
CURVE C - 48% CHEM.
CURVE D - 47% CHEM.
CURVE E - 34% CHEM.
CURVE F - 23% CHEM.
PER CENT SCREENED YIELD
CONCENTRATION GM. Na_2O/L
COOKING TIME (MIN)
PER CENT WOOD REMOVED
PER CENT SCREENINGS IN PULP
A-B
C-D
E
F

Fig. 5. Effect of per cent alkali in pulping slash pine

content of pulps whose total yields range from 50 to 60% should be a very good indication that the pulping reaction is becoming more uniform. In other words, the steeper the slope when per cent screenings is plotted against total yield, the more uniform the reaction.

Elimination of the 12.0% of material which is under 8 mesh should improve strength of pulp as well as increase yield. This undersize material contains a large amount of wood which is shorter in the grain direction than the original chips. Therefore, a definite percentage of fibers was cut before cooking, thus reducing the strength of the resultant pulps, particularly in tearing strength.

Effect of the Pulping Variables on Chemical Analysis of Pulps

Lignin and pentosan content and permanganate numbers for most of the pulps are listed in Table I. Lignin content of screened pulp decreases with per cent screenings in pulps, as would be expected, but lignin content seems to be somewhat higher for the rapidly cooking pulps than for slowly cooked pulps with a similar screenings content. For example, cook no. 157, containing only 2.0% screenings, produced a screened pulp with 8.5% lignin. This would indicate that it might be advantageous in continuous pulping by chemical injection to cut off fortification of the liquor near the end of the cook. This would permit a milder reaction while the lignin content of the pulped material is being lowered.

It will be noted that pentosan content is quite low in all pulps. The cooks in which liquor concentration was held at 20 g.p.l. produced pulps with the highest pentosan. However, the reaction rates at this concentration are so low that 20 to 60 min. are needed for thorough pulping. It might be possible to increase pentosan content to as high as 5.0% if steam pressure could be increased to 200 to 210 p.s.i.g. so that the pulping reaction could be completed in 15 min. When a new liquor tank is installed in the experimental equipment it is hoped to explore these higher pressures.

Pentosan content of pulps does not seem to be improved by conserving the pentosan in the presteaming operation. As mentioned earlier, Na_2SO_3 was used instead of most of the Na_2CO_3 in some of the presteaming operations. Even though only 20.9% of the pentosan was dissolved by this method, as compared to a 27.3% loss when Na_2CO_3 alone was used in presteaming, no appreciable saving in pentosan was apparent in the cooked pulp. Similarly, pentosan content of pulps appeared to be about the same, regardless of whether the wood was steamed at 125 or 170 p.s.i.

The relationship between pentosan content of pulps and concentration of cooking liquor is shown in Fig. 6. The solid line represents the average pentosan content of pulps cooked under all conditions. The two dotted lines indicate the approximate spread in pentosan content which might be expected from variations in steam pressure and cooking time at any one concentration. The curves do not resemble the relationship previously found for the hardwoods (*8*). This can be explained in part by the fact that, in hardwood pulping, pentosan content represents practically all of the hemicellulose in the pulp but, with the pines, pentosans are only about half of the total hemicellulose. This was compensated for, insofar as possible, by doubling the scale of the horizontal or pentosan axis in plotting the pine pulps. It would appear that the last 2 to 3% of hemicellulose would offer more resistance to removal when cooking pine than would be true of the hardwoods.

A very good relationship was found between permanganate number and lignin content of pulps. This is illustrated in Fig. 7. The advantage of using 50 ml. of 0.1 *N* permanganate can be seen in this curve. If the TAPPI standard method had been followed, two curves would have resulted, one for the group evaluated with 25 ml. of permanganate, another for those requiring 40 ml. The pulps containing over 14% lignin would probably have shown permanganate numbers of 39 or less.

Effect of Per Cent Alkali in Pulping

The yield and analytical data for the study of the effect of changes in per cent alkali are listed in Table II and are shown graphically in Fig. 5. Per cent chemical was varied by changing the liquor-wood ratio, starting with the liquor-wood ratio of 40:1 used in previous experiments and scaling downward to the lowest value of 6.8:1. No appreciable change in pulping rate could be detected by decreasing the per cent chemical from 133 to 72%. Further decreases in chemical resulted in definite decreases in pulping rate. The milder conditions caused by decrease in per cent chemical and the corresponding decrease in effective concentration did not result in increased screened yields of pulp, even though longer cooking times were required to reach max-

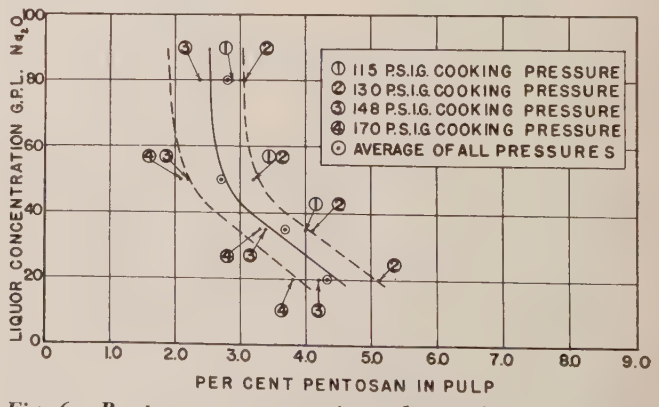
① 115 P.S.I.G. COOKING PRESSURE
② 130 P.S.I.G. COOKING PRESSURE
③ 148 P.S.I.G. COOKING PRESSURE
④ 170 P.S.I.G. COOKING PRESSURE
⊙ AVERAGE OF ALL PRESSURES
LIQUOR CONCENTRATION G.P.L. Na_2O
PER CENT PENTOSAN IN PULP

Fig. 6. Pentosan-concentration relationship in continuous pulping of slash pine

imum screening yield. This would indicate that the decreased contact time between liquor and cellulosic materials which results from the use of more drastic cooking conditions nullifies any degrading effect which high concentration might tend to promote.

It will be noted that there is a tendency toward higher pentosan in the pulps resulting from the cooks using lower values of per cent chemical. This is most noticeable in the cooks using 23% chemical. The time required for thorough pulping under these conditions becomes quite long for continuous methods, about 60 min. Retention of pentosan might be promoted in continuous pulping by injection methods if concentration is held constant by liquor fortification, then allowed to drop by discontinuing fortification in the latter part of the cook. This is the same method suggested earlier for delignification without excessive loss in yield.

Apparently the per cent chemical employed in the cook does not affect the bleachability of pulp. Permanganate numbers of the pulps fall on the same curve as was found for the pulps cooked with 133% chemical (40:1 liquor-wood ratio).

Black liquors were analyzed in this series of cooks because it was apparent that there would be sufficient drop in concentration to warrant calculation of chemical consumption. The method of analysis of TAPPI Standard T 625 was used—sulphides being determined by evolution of H_2S. It was found that, from these analyses, the average liquor consumption was 0.246 gram Na_2O per gram of wood dissolved. Individual values calculated from analysis agreed very well with the average. From this average value of chemical consumption and from the yield and liquor-wood ratio data it was possible to calculate concentrations throughout all the cooks. The calculated concentrations are the ones plotted in Fig. 5.

Effect of Chip Size in Pulping

This study was divided into two parts. The first part, in which various size fractions of presteamed hammer-milled pine chips were pulped, is reported in Table IIIB and shown graphically in Fig. 4. The second part, in which chips were hammer-milled without presteaming, is listed in Table IIIA and shown in Fig. 3.

There is no significant difference in the rate of wood removal between the over-all mixture of presteamed shredded wood and its 4-mesh fraction. Wood removal rate increases as cross section of the chip decreases to 6 and 8 mesh. The over-all mixture is converted to screened pulp faster than its 4-mesh fraction. The screened yield curves of Fig. 4 indicate clearly the trend that cross-section dimension of the chip has on the rate of production of screened pulp. The data substantiate the statement made earlier that a closely regulated product from the hammer mill, in the size range of −4 to +8 should give the greatest uniformity of reaction and the maximum yield of screened pulp.

Dry hammer-milling of chips prior to pulping does

Table III. Effect of Chip Size on Pulping Rate of Slash Pine

Chip size	*Cook No.*	*Liquor[a] conc., g.p.l.*	*Cooking pressure, p.s.i.g.*	*Cooking time min.*	*Yield, % of steamed wood* — *Total*	*Screened*	*Screenings, % of pulp*	*Analysis of pulp* — *Lignin, %*	*Alpha cellulose, %*	*Pentosan, %*
			A. Size Reduction Obtained by Hammer-Milling Dry Chips							
Dry standard size chips	423	50	148	5	73.3	2.8	96.2	...	...	...
	410	50	148	10	64.4	15.5	76.0	15.9	82.0	3.6
	411	50	148	20	50.2	34.7	30.9	5.2	91.8	2.3
	424	50	148	30	44.2	39.0	12.7	5.4	93.7	2.3
	425	50	148	60	36.4	36.3	0.3	2.0	95.7	1.7
Water - soaked standard size chips	418	50	148	5	75.8	2.4	96.8	...	...	...
	419	50	148	10	61.8	16.6	73.2	15.4	84.1	3.8
	420	50	148	15	54.1	29.8	44.8	11.3	88.2	3.1
	421	50	148	20	48.4	35.3	27.2	8.4	91.2	3.8
	422	50	148	30	42.6	38.8	8.5	...	...	...
+4 Mesh after hammer-milling	334	50	148	10	58.2	22.5	61.0	...	...	...
	335	50	148	15	50.6	34.5	31.8	...	...	...
	286	50	148	16	50.8	35.5	29.9	...	...	...
	336	50	148	20	45.1	38.9	13.7	...	...	...
−4+6 Mesh after hammer-milling	337	50	148	10	53.4	32.8	38.4	...	...	...
	338	50	148	15	46.7	43.0	9.0	7.9	...	2.3
	339	50	148	20	43.0	42.9	0.7	4.8	...	2.1
−6+8 Mesh after hammer-milling	340	50	148	10	52.3	44.0	15.9	12.2	..	3.4
	341	50	148	15	45.8	45.5	0.7	6.8	...	2.3
	342	50	148	20	43.2	43.3	0.0	...	..	...
			B. Size Reduction Obtained by Hammer-Milling Presteamed Chips							
Unscreened hammer-milled product	413	50	148	5	64.8	7.2	88.8	...	...	...
	414	50	148	10	53.1	43.4	17.8	14.3	84.6	2.5
	415	50	148	15	47.3	45.6	3.4	10.9	87.4	2.3
	416	50	148	20	43.8	43.5	0.4	4.6	92.5	1.7
	417	50	148	30	40.7	40.6	0.1	...	...	...
	426	50	148	60	36.2	36.2	0.0	...	...	...
+4 Mesh fraction of hammer-milled product	321	50	148	11	48.5	42.2	12.9	8.6	90.3	2.4
	254	50	148	15	48.0	45.2	4.4	5.2	92.4	2.0
	323	50	148	20	43.4	43.2	0.8	3.4	94.4	1.8
−4+6 Mesh fraction of hammer-milled product	324	50	148	10	50.2	46.6	7.1	10.4	87.4	2.5
	325	50	148	15	44.0	44.0	0.4	5.3	94.8	2.1
	326	50	148	20	43.2	43.1	0.1	3.4	95.8	0.8
−6+8 Mesh fraction of hammer-milled product	327	50	148	10	48.7	48.2	0.9	10.2	86.2	2.3
	328	50	148	15	44.2	44.2	0.0	4.9	92.3	1.7
	329	50	148	20	42.4	42.4	0.0	...	...	...

[a] Liquor-wood ratio 40:1. Sulphidity of 25% used throughout.

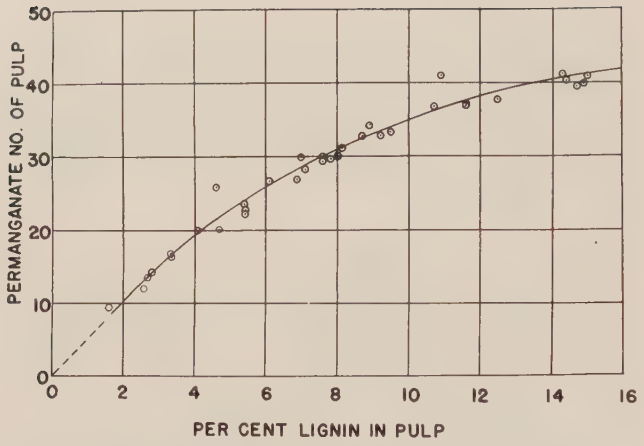

Fig. 7. Permanganate numbers of slash pine pulps (50 ml. of 0.1 N permanganate used)

not promote as high a reaction rate as does presteaming before hammer-milling. This is undoubtedly due, in part, to the fact that presteaming softens the chips so that their ends are broomed out by the hammers, whereas the milling action rounds off the ends of the untreated chips and gives them a polished appearance. The bulk density of the presteamed hammer-milled chips is considerably less than the dry hammer-milled material (*9*).

The same effect of cross-section size of the dry hammer-milled chips on rate of pulping, yield of screened pulp, and per cent screenings can be seen in Fig. 3 as was apparent with presteamed chips. However, all rates are lower than when chips are presteamed. This point is made clear by the inclusion of the curve for the presteamed shredded mixture with the curves for the dry hammer-milled curves. It can be seen that the over-all mixture of presteamed material pulps as readily as the −6+8-mesh fraction of dry hammer-milled material.

The cooking curves for untreated full-size chips are included to show the increased reaction rates that can be realized by mechanical treatment. The fact is also brought out that moisture content of the chip has no effect on reaction rate if the chip moisture does not seriously affect concentration of the cooking liquor.

The data do not indicate that decreased chip size promotes the removal of pentosan. All pentosan values of Table IIIB are very low, falling near the left-hand dotted curve of Fig. 6. Pentosan content of pulps may be improved by the use of the smaller cross-section material because the increased surface area will result in higher reaction rate and permit the use of lower concentration or cooking time to attain the same degree of pulping.

The very low pentosan values in Table IIIA for the pulping of full-size chips indicate that conservation of pentosan in presteaming will not be reflected in a saving of pentosan in the pulp. The full-size chips, not being presteamed or hammer-milled, were reduced to pulps of just as low a pentosan content as if 30% of the pentosan had been removed by presteaming. Here is another indication that surface area does not influence pentosan removal. The chief variable controlling pentosan is undoubtedly concentration, with minor effects due to steam pressure and cooking time.

Physical Strength of Pulps

Physical strength data for several pulps are listed in Table IV, along with pertinent cooking data. Pulp no. 636 was cooked for 4.0 hr. by batch methods and contained 4.1% lignin and 8.5% pentosan, with a permanganate number of 20.6. Pulp no. 633, cooked for 2.0 hr by batch methods, contained 5.9% lignin and 8.1% pentosan, with a permanganate number of 25.8. The permanganate numbers of both of these pulps fell on the same curve, Fig. 6, that was developed for pulps cooked by continuous methods.

All pulps other than 633 and 636 were prepared from presteamed, hammer-milled chips and cooked by continuous methods. Cooking conditions and pentosan content of the pulps were as follows:

Pulp no. 473—Concentration 50 g.p.l.; liquor ratio 40:1; steam pressure 148 p.s.i.; cooking time 15 min.; pentosan in pulp 3.0%

Pulp no. 480—Concentration 35 g.p.l.; liquor ratio 40:1; steam pressure 170 p.s.i.; cooking time 15 min.; pentosan in pulp 3.6%

Pulp no. 567—Concentration 20 g.p.l.; liquor ratio 40:1; steam pressure, 170 p.s.i.; cooking time 27 min.; pentosan in pulp 3.6%

Pulp no. 591—Concentration 20 g.p.l.; liquor ratio 40:1; steam pressure 170 p.s.i.; cooking time 17 min.; pentosan in pulp 3.9%

Pulp no. 542—Concentration 40 g.p.l.; liquor ratio 5.2:1 (final concentration 13.4 g.p.l.); steam pressure 170 p.s.i.; cooking time 30 min.; pentosan in pulp 5.3%

Strength characteristics of the pulps cooked under continuous methods at 20 g.p.l. (nos. 567 and 591) are shown graphically in Fig. 8, along with those of the batch type pulps. In Fig. 9 are plotted the other continuously cooked pulps, with cook no. 567 being repeated for comparative purposes.

The data show that burst and tensile strength are increased by decreases in liquor concentration but concentration has the opposite effect on tearing strength. Bursting and tensile strengths of all pulps produced by continuous methods are inferior to those resulting from batch methods. However, a pulp cooked rapidly at 20 g.p.l. is 94% as strong in both tensile and bursting strength as the batch pulp cooked in 2.0 hr., and 92% as strong in tensile and 93% as strong in burst as the 4.0 hr. pulp.

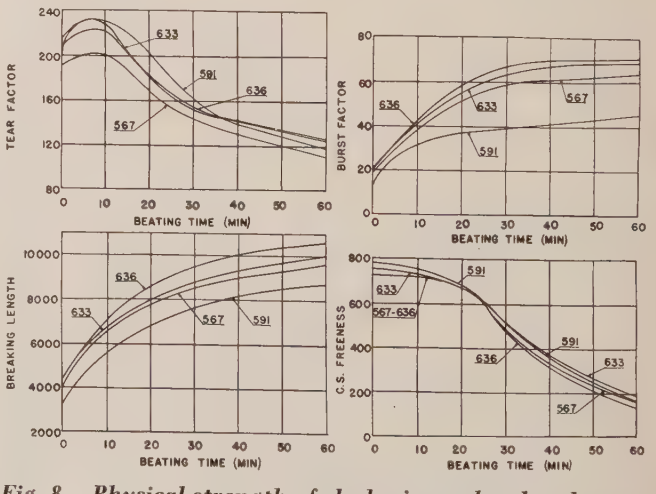

Fig. 8. Physical strength of slash pine pulps, batch types and continuous types, 20 g.p.l.

Numbers designate cooks described in Table IV.

The differences in bursting and tensile strength cannot be accounted for by pentosan content of pulps. All of the rapidly cooked pulps were low in pentosan, in the range of 3.0 to 3.9%, even though there was wide divergence in burst and tensile strengths. On the other hand, pulp no. 567, containing only 3.6% pentosan, was practically as strong in burst and tensile as the batch type pulps, containing 8.1 to 8.5% pentosan. Apparently concentration has some effect on physical strength other than its control over pentosan content of the pulp.

Another pulp, no. 542, cooked by continuous methods but at low liquor-wood ratio and containing 5.3% pentosan, was equal in bursting strength to the 20 g.p.l. pulp containing 3.6% pentosan, and slightly superior to it in tensile strength.

The freeness development curves also seem to contradict accepted theories on the relationship between pentosan content and strength of pulps. Numerous references in the literature state that high-pentosan pulps develop hydration rapidly while pulps low in pentosan require longer beating time. The freeness curves for the two pulps cooked at 20 g.p.l. (3.6 to 3.9% pentosan) were almost identical with the batch type pulps (8.1 to 8.5% pentosan). One of the 20 g.p.l. pulps was high in burst and tensile strength while the other was much weaker in these characteristics even though their freeness curves were the same. Another contradiction is indicated in the fact that the 35 and 50 g.p.l. pulps were slow in developing hydration compared to the 20 g.p.l. pulps even though they all had about the same pentosan content.

All things considered, it appears evident that pulps can be produced continuously from pine which are very close in strength to the best pulps produced by batch methods with long cooking cycles. Concentration of cooking liquor should be kept at a minimum. As methods of mechanical subdivision of chips for surface area expansion are perfected it may be possible to increase the strength properties of pulps beyond those realized thus far.

Maintenance of Concentration at Low Liquor-Wood Ratios by Injection Methods

In all of the experimental work carried out thus far concentration of cooking liquor has been maintained by use of a very high liquor-wood ratio, 40:1, using such a high excess of chemical that the concentration drop caused by cooking is negligible. It is planned, in the pilot-plant development of the process, to maintain concentration by injection of small amounts of high-concentration alkali at several points along the continuous digester, thus permitting the employment of normal commercial liquor-wood ratios. For that reason, a set of sample calculations are included in this report in order to show the magnitude of the quantities involved and the extent of the liquor dilution caused by injection. Figure 10 is a sketch of the proposed digester to be used in the pilot plant. The calculations are as follows:

Calculations for Liquor Injection on a Pilot-Plant Continuous Digester

1. *Conditions of cooking*
   Average liquor concentration, 20 g.p.l. Na_2O
   Per cent sulphidity, 25%
   Liquor-wood ratio, 5:1
   Cooking pressure, 170 p.s.i.g.
   Cooking time, 23 min. (47.3% total yield)

Table IV. Effect of High-Speed Pulping on Physical Strength of Slash Pine Pulps

Cook No.	*Wood used*	*Steam pressure, p.s.i.g.*	*Liquor conc., g.p.l.*	*Liquor-wood ratio*	*Cooking time, min.*	*Total yield, % of orig. wood*	*Screenings, % of total yield*	*Beating, time, min.*	*Freeness, Can. Std., ml.*	*Breaking length, meters*	*Burst factor*	*Tear factor*
636	Mill-size chips	115	50	3.36:1	235[a]	45.6	1.9	0	728	4,347	21.2	213
								7	722	6,365	35.6	232
								25	597	9,090	63.8	162
								50	208	10,380	71.6	133
								70	79	10,840	70.1	116
633	Mill-size chips	115	50	3.36:1	120[b]	48.8	13.5	0	730	4,379	21.4	207
								7	745	6,143	35.6	223
								25	617	8,430	60.1	166
								50	265	9,450	68.6	134
								75	96	10,590	69.8	115
591	Steamed hammer-milled chips	170	20	40:1	17	51.8	12.6	0	768	3,265	13.5	183
								7	777	4,875	29.0	233
								25	612	7,270	37.9	179
								50	246	8,530	41.4	128
								75	72	8,910	48.2	101
567	Steamed hammer-milled chips	170	20	40:1	27	44.5	3.2	0	755	3,990	19.1	190
								8	706	6,200	35.5	202
								25	608	8,210	56.2	153
								50	230	9,000	62.0	120
								70	88	9,950	65.7	100
473	Steamed hammer-milled chips	148	50	40:1	15	46.4	2.7	0	732	2,745	12.9	151
								20	683	5,435	37.4	199
								45	451	7,240	49.9	154
								65	230	7,740	55.9	156
								85	89	8,425	57.0	116
480	Steamed hammer-milled chips	170	35	40:1	15	46.8	3.3	0	718	3,235	15.4	188
								20	686	6,060	41.6	204
								45	416	7,560	52.5	164
								65	203	8,820	55.6	138
								85	77	9,280	62.9	127
542	Steamed hammer-milled chips	170	40	5.2:1	30	46.8	5.1	0	708	3,650	16.4	203
								7	695	6,260	34.2	216
								25	595	8,770	56.0	147
								45	245	9,270	61.7	126
								65	85	10,100	60.0	105

[a] 30 min. at 212°F., 135 min. at 212 to 347°F.
[b] 60 min. to 347°F.

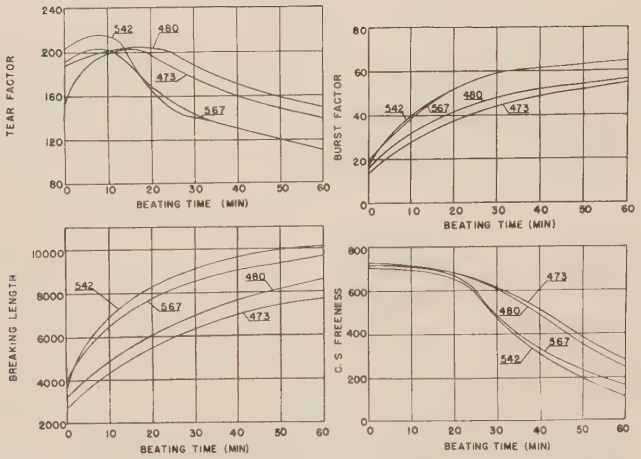

Fig. 9. Physical strength of slash pine pulps. Continuous pulping at 20, 35, and 50 g.p.l. and low liquor ratio (40 g.p.l. initial concentration)

Numbers designate cooks described in Table IV.

Liquor concentration variation, 22 g.p.l. at start, 18 g.p.l. before fortification
Fortification liquor, 40% NaOH (31% Na_2O)
Specific gravity of 20 g.p.l. liquor, 1.02
Moisture in chips, 45%
Time-per cent wood removal relationship as shown by 170°-F. curve, Fig. 2
Chemical consumption (Table II) = 0.246 g. Na_2O/g. wood dissolved

2. *Injection times*
Basis of calculations, 100 g. moisture-free chips
Weight of initial cooking liquor = $5 \times 100 = 500$ g.

Volume of liquor (including water in chips) = $\frac{500}{1000 \times 1.02}$ = 0.49 l.

Per cent chemical at start of cook = $0.49 \times 22 \frac{100}{100}$ = 10.78%

Water in chips = $100 \times \frac{45}{55}$ = 81.8 g. = 0.0818 l.

Fresh liquor = 0.490 − 0.0818 = 0.4082 l.

Concentration of white liquor = $\frac{10.78}{0.4082}$ = 26.4 g.p.l.

Allowing concentration to drop to 18 g.p.l. before first fortification
Grams Na_2O consumed = $10.78 - 0.49 \times 18 = 1.96$ g.

Wood consumed = $\frac{1.96}{0.246}$ = 7.98 or 8.0 g. moisture-free wood

Time of 8.0% wood removal (Fig. 2) = 0.8 min. = time of 1st injection
At this injection, fortify with sufficient chemical to make up the 1.96 g. Na_2O consumed. If this liquor is added as 40% NaOH, gram water with injection = $\frac{1.96 \times 0.69}{0.31}$ = 4.36 g.

Second injection:
Total wood removed = $2 \times 8.0 = 16.0$ g.
Time for second injection = 2.5 min. (Fig. 2)
Third injection:
Wood removed = $3 \times 8.0 = 24.0$ g.
Time for third injection = 4.3 min.
Fourth injection:
Wood removed = $4 \times 8.0 = 32$ g.
Time for fourth injection = 6.7 min.
Fifth injection:
Wood removed = $5 \times 8.0 = 40.0$ g.
Time for fifth injection = 10.5 min.
Sixth injection:
Wood removed = $6 \times 8.0 = 48.0$ g.
Time for sixth injection = 17.0 min.
Seventh injection:
Wood removed = $7 \times 8 = 56.0$ g.
Therefore, a seventh injection is unnecessary, since total wood removed in 23-min. cook is 100 − 47.3 = 52.7 g.

Wood consumed between sixth injection and end of cook = 52.7 − 48.0 = 4.7 g.
Chemical consumed = $4.7 \times 0.246 = 1.155$ g.

Concentration at end of cook = $\frac{10.78 - 1.155}{0.49}$ = 19.63 g.p.l.

Total water added by injection = $6 \times 4.36 = 26.16$ g. = 0.0262 l.

% dilution = $\frac{0.0262 \times 100}{0.490}$ = 4.93%

Total Na_2O used in cycle = $10.78 + 6 \times 1.96 = 22.54$ g. or 22.54% on basis of moisture-free wood

3. *Pilot-plant digester characteristics* (Fig. 8)
Shift basis of calculations from 100 g. moisture-free wood to 23-min. operation of pilot-plant digester
Diameter = 17.25 in. i.d.
Effective filled length = 15.0 ft. (estimated)
Assume 15% of digester volume taken up by partition and conveyor
Diameter of liquor sump = 12 in.
Length of sump = 24 in.

Effective digester volume = $\frac{0.85 \times \pi \times 17.25^2 \times 15}{4 \times 144}$
= 20.65 cu. ft.

Sump volume = $\frac{\pi \times 1 \times 2}{4}$ = 1.57 cu. ft.

4. *Capacity of digester*
Experimental data showed that shredded pine has the following bulk characteristics when dropped, without tamping, into a container and just covered with liquor at 20 g.p.l.
1 cu. ft. will hold 9.44 lb. moisture-free wood (shredded wood containing 55% water)
1 cu. ft. will hold 56.1 lb. of 20 g.p.l. liquor, in addition to the wood
Liquor at 22 g.p.l. = 2.155% Na_2O
$56.1 \times 0.02155 = 1.21$ lb. Na_2O in immersion liquor

% chemical = $\frac{1.21 \times 100}{9.44}$ = 12.83%

However, only 10.78% chemical will be used in the digester. Therefore,
Weight of chemical per cubic foot of shredded wood = $9.44 \times 0.1078 = 1.018$ lb.

Weight of liquor per cubic foot of wood = $\frac{1.018}{0.02155}$ = 47.2 lb.

% consistency at start of cook = $\frac{9.44 \times 100}{9.44 + 47.2}$ = 16.66%

Capacity of digester per 23-min. cycle, assuming 85% fillage of effective length = $0.85 \times 20.65 \times 9.44 \times 0.473$ = 78 lb. moisture-free pulp per cycle

Capacity per 24 hr. = $\frac{78.0 \times 60 \times 24}{23 \times 2000}$ = 2.44 tons

Weight of moisture-free wood to digester = $\frac{78.0}{0.473}$ = 165.3 lb. per 23 min.

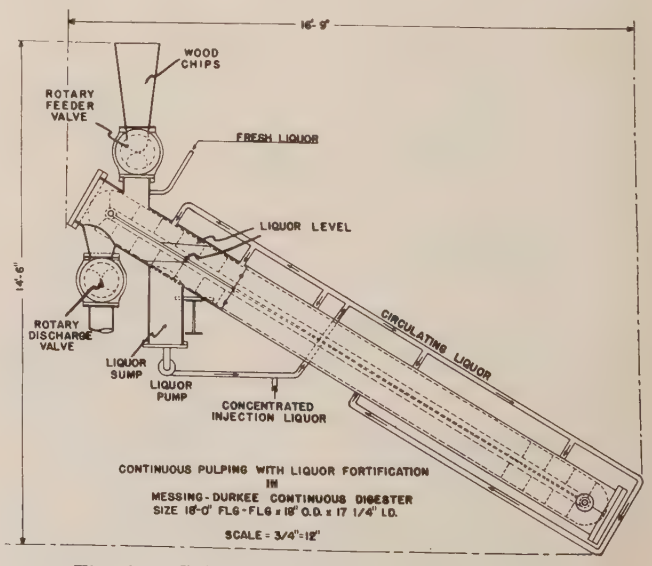

Fig. 10. Schematic diagram of pilot digester

Total liquor content of digester (without recirculation) = $0.85 \times 20.65 \times 47.2 + 1.57 \times 62.3 \times 1.02 = 827 + 100$ = 927 lb. or $\frac{927}{8.33 \times 1.02} = 109.2$ gal.

5. *Digester liquor circulation*
Normal circulation rate in batch pulping = 0.7 g.p.m. per cu. ft. of digester capacity. Data from one mill showed 16.7 tons dry pulp per blow in a digester of 4300 cu. ft. capacity

Batch circulation rate per ton dry pulp = $\frac{4300 \times 0.7}{16.7}$ = 180 g.p.m.

Pulp capacity of pilot-plant digester = $\frac{78.0}{2000} = 0.0390$ ton

Circulation rate = $180 \times 0.0390 = 7.02$ g.p.m.

6. *Total volume, including liquor circulation*
Volume of wet chips = $0.85 \times 20.65 = 17.55$ cu. ft. per 23 min.
Original liquor with chip = $17.55 \times 47.2 = 828$ lb. = $\frac{828}{8.33 \times 1.02} = 97.5$ gal.
Chips will take up an additional amount of liquor equal to $17.55\ (56.1 - 47.2) = 156.2$ lb. or $\frac{156.2}{8.33 \times 1.02} = 18.37$ gal.
Total circulating liquor added = $7.02 \times 23 = 161.5$ gal.
Volume occupied by circulating liquor = $161.5 - 18.37 = 143.1$ g.p.l. or 19.2 cu. ft.
Total volume of liquor passing through digester per cycle = $\frac{17.55 \times 56.1}{62.3 \times 1.02} + \frac{143.1}{7.48} = 15.5 + 19.2 = 34.7$ cu. ft.

Cross section of liquor travel = $\frac{0.85 \times \pi \times 17.25^2}{2 \times 4 \times 144}$ = 0.688 sq. ft.

Approximate velocity of liquor = $\frac{34.7}{23 \times 0.688} = 2.19$ f.p.m.

Approximate velocity of conveyor and chips = $\frac{2 \times 18}{23}$ = 1.565 f.p.m.

Therefore, liquor will travel slightly faster in the latter part of the cook than the pulp

7. *Injection liquor necessary*
Weight moisture-free wood charged = 165.3 lb.
Weight of wood dissolved = $165.3 \times 0.527 = 87$ lb.
Chemical consumed = $87.0 \times 0.246 = 21.4$ lb. Na_2O
This chemical is added as 40% NaOH (31% Na_2O, sp. gr. 1.43, lb. Na_2O per gal. 3.70)

Vol. injection liquor = $\frac{21.4}{3.70} = 5.78$ gal. $= 5.78 \times 8.33 \times 1.43 = 69.0$ lb.

Water in injection liquor = $69.0 \times 0.60 = 41.4$ lb.

8. *Concentration of circulation liquor after fortification*
Conc. of circulation liquor leaving digester = 19.63 g.p.l. = $19.63 \times 0.00833 = 0.1637$ lb. per gal.
Active Na_2O carried = $161.5 \times 0.1637 = 26.45$ lb.
Active Na_2O after injection = $26.45 + 21.4 = 47.85$ lb.
Vol. of fortified liquor = $161.5 + 5.78 = 167.28$ gal.

Conc. after fortification = $\frac{47.85}{167.28} = 0.286$ lb. per gal. = 34.2 g. Na_2O/l.

If the above calculations are repeated, using duplicate cooking conditions except for the liquor-wood ratio which is now 10:1 instead of the previous 5:1, the following results are obtained.

Per cent chemical = 21.58% added with chips
Three injections required:
1st injection at 1.75 min. cooking time
2nd injection at 8.5 min. cooking time
3rd injection at 17.0 min. cooking time
Concentration at end of cook = 20.9 g.p.l.
Water addition due to injection = 2.68% of total water
Total Na_2O used in cycle = 33.4%
Volume of circulated liquor and concentration of circulating liquor after reinforcing are the same as when a liquor-wood ratio of 5:1 is used

The above calculations were made for the lowest practical concentration, 20 g.p.l. Use of higher concentration of cooking liquor would involve fewer injections since the allowable 10% drop in concentration would involve the consumption of more chemical and, consequently, a greater degree of cooking between injections. Also, higher concentrations would permit the use of lower liquor-wood ratios for the same per cent chemical. It is therefore evident from the calculations that the number of injections of fortifying chemical need never exceed six or seven and the degree of dilution of black liquor by fortification will always be of a minor nature.

The pilot-plant investigation should open up possibilities of the process which could not be studied in the small-scale equipment. Velocity of reaction and cooking time may be varied by manipulation of the fortifying chemical. Decreases in concentration of varying magnitude after the cook has been well started may be carried out and their effects on yield and chemical analysis evaluated. The equipment will permit the production of sufficient quantities of pulp so that a paper machine run on the pulp may be made.

CONCLUSIONS

Chemical pulps may be produced from slash pine over a wide range of concentrations and steam pressures by continuous methods. Screened yields as high as 46.0% of the original wood (48.4% of wood charged to the digester) may be realized in 15 to 20 min. cooking time. It is necessary to presteam and hammer-mill the chips berore pulping in order to attain high yields. Presteaming for 10 min. at 125 p.s.i.g. is sufficient for adequate softening of the chips.

Pentosan content of pulps cooked at sustained concentration is considerably lower than that of pulps cooked by commercial batch methods. Maximum pentosan precentage attained by continuous methods is 4.0% or less.

Physical strength of pulps appears to be a function of concentration of cooking liquor, maximum strengths resulting from the lowest concentrations. At 20 g.p.l., pulps about 95% as strong as the best commercial pulps in tensile and bursting strength can be attained. The data do not indicate that pentosan content of the pulp controls bursting or tensile strength.

Easily bleached pulps, as indicated by permanganate number, can be produced by continuous methods. The relationship between lignin content and permanganate number is the same as for conventional sulphate pulps.

LITERATURE CITED

1. Nolan, W. J., Harvin, R. L., Reeder, L. M., and Rothrock, C. W., Jr., *Tappi* 34, No. 12: 529–538 (Dec., 1951).
2. Nolan, W. J., and Brown, W. F., *Tappi* 35, No. 11: 505–510 (Nov., 1952).
3. March, R. E., *Paper Trade J.* 127, No. 17: 51–57 (Oct. 21, 1948).
4. Galley, W., *Tappi* 32, No. 10: 457–462 (Oct., 1949).
5. Cottrall, L. D., *Tappi* 33, No. 9: 471–480 (Sept., 1950).
6. Ratliff, F. T., *Tappi* 32, No. 8: 357–367 (Aug., 1949).
7. Harvin, R. L., Hills, G. B., Jr., Rothrock, C. W., and Nolan, W. J., *Tappi* 33, No. 7: 338–343 (July, 1950).
8. Nolan, W. J., and Brown, W. F., *Pulp Paper Mag. Canada* 53, No. 9: 98–110 (Aug., 1952).
9. Nolan, W. J., and Brown, W. F., *Tappi* 35, No. 9: 425–432 (Sept., 1952).

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Extractives of Aspenwood and Bark

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The extractives of aspenwood and oak include a considerable portion soluble in ether and of high fatty acid content. This portion often contributes to the formation of hardwood pitch and may upon mixture with resins from size or from softwood pulps yield products of an extremely tacky character. Seasoning markedly decreased the ether-soluble material in both wood and bark.

Hardwoods and hardwood pulps contain but little resinous material, and the possible contribution of hardwood extractives to the accumulation of deposits in mill operation is frequently overlooked. Many instances of mill troubles have involved the presence of aspenwood, and the present study was designed to furnish additional background on both wood and bark for the examination of "hardwood pitch."

The extractives of aspenwood have been determined by the Forest Products Laboratory, which reported (*1*) solubilities in alcohol-benzene, ether, and hot water of 2.9, 1.0, and 2.8%, respectively, for one sample and 2.8, 1.1, and 1.5% for another. Ritter (*2*) reported extractives soluble in hot water 2.00%, in alcohol-benzene 1.52%, and in ether 1.00%. Keller and McGovern (*3*) found 2.8% soluble in alcohol-benzene, 0.6% soluble in ether, and 3.0% soluble in hot water. Wise, *et al.* (*4*) reported 4.3% total extractives (alcohol and hot water).

Work on the extractives of aspen bark has been done at the University of Minnesota [reported in (*2*)]. One proximate analysis gave 23.06% soluble in hot water, 15.13% soluble in ether, and 23.52% soluble in alcohol-benzene. In another instance, successive extractions gave for the whole bark 3.88% soluble in petroleum ether, 2.07% in ether, 0.49% in benzene, 17.05% in alcohol, and 12.89% in hot water.

EXPERIMENTAL

The bole and bark for analysis were obtained from a quaking aspen (*Populus tremuloides*) tree 4.5 in. in diameter at a height of 4 ft. The bark was separated from the wood, air dried, and ground in a Wiley mill to pass a 40-mesh screen. The bole was cut into disks which were partially air dried and reduced to sawdust. Both the ground bark and the sawdust were further air dried for a few hours before analysis.

Determination of Extractive Content

The bark was extracted in a Soxhlet extractor successively with ethyl ether, alcohol-benzene (1:2), ethyl alcohol, and hot water. The wood was extracted similarly but the alcohol extraction was omitted. Each extraction was carried out for 6 hours. The results are given in Table I. All analyses were carried out in duplicate and the averages are reported.

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The ether-soluble portion of wood or pulp is generally considered responsible for the accumulation of troublesome deposits in mill operation. From this viewpoint, the high ether-soluble content of aspenwood is significant.

The ether-soluble materials isolated were soft and generally nontacky. This is to be expected from the fact that they consist chiefly of fatty acids. In this, they are quite similar to the fatty acid fractions isolated from softwoods or softwood pitch accumulations, after separation of the resin acid fractions.

Table I. Extractives in Aspenwood and Bark[a]

Solvent	Freshly cut		Seasoned	
	Wood	Bark	Wood	Bark
Ether	2.7	9.6	1.5	3.4
Alcohol-benzene	1.1	10.8	2.1	7.3
Alcohol	[b]	1.4	[b]	1.0
Hot water	1.1	4.1	1.8	4.9
Total	4.9	25.9	5.4	16.6

[a] Per cent on oven-dry, unextracted wood basis.
[b] Not determined.

Resin acids, from softwood extractives or from rosin size, are normally hard and brittle at ordinary temperatures. However, it is well known that *mixtures of resin and unsaturated fatty acids almost invariably give rise to extremely tacky products.* The incorporation of hardwood pulps in furnishes containing softwood pulps or rosin size may accentuate the formation of sticky deposits by bringing the resin-fatty acid ratio into a critical range for a given set of operating conditions. However, hardwood extractives alone appear to be responsible for the accumulation of some troublesome deposits.

Because wood frequently is seasoned before use, the effect of seasoning on the amount of extractives in wood and bark was determined. Sections of the unbarked bole were split and stored at 50 to 75°F. for 7 months. The wood and bark were then prepared for analysis as described above. The seasoned wood had a moisture content of 5.6%. The analyses are compared with those of freshly cut wood in Table I. A marked decrease in ether solubility of both wood and bark is observed after seasoning. It may be expected that seasoned aspenwood will give somewhat less "pitch" trouble than green wood, as is the case with softwoods. In the wood, the materials which become insoluble in ether upon aging are still soluble in alcohol-benzene.

Both the ether and alcohol-benzene solubles decreased upon aging of the bark. However, the high extractive content in either seasoned or unseasoned bark may give rise to difficulty in later operations on such products as semichemical pulps from unbarked aspenwood.

Analysis of Ether-Soluble Extractives

For isolation of larger quantities of the ether extrac-

tives, portions of 400 grams of bark and 650 grams of wood were extracted by the same method as that used for the quantitative test.

The ether-soluble material was separated into unsaponifiable, fatty acid, and resin acid fractions. The iodine number was determined on the total ether-soluble material and on the separated fatty acids. The results are shown in Table II. The low recovery of unsaponifiable and saponifiable material in the ether extract of the bark suggests the presence of acids and neutral materials which are relatively soluble in water. The presence of phenolic substances in the alcohol-benzene extract has been noted (*2*).

Table II. Analysis of the Ether Extractives

	Wood	*Bark*
Iodine no. [a, b]	154	106
Unsaponifiable matter, %[a]	17.7	10.1
Resin acids, %[a]	1.7	8.5
Fatty acids, %[a, c]	72.4	33.7
Iodine no. of fatty acids[d]	154	109
Recovery, %[e]	91.8	52.3

[a] On the total ether extract.
[b] By the Hanus method (*5*).
[c] After two selective esterification steps. A modification of the Wolff and Scholze method (*6*) was used.
[d] On the fatty acids recovered following the first esterification step.
[e] The sum of unsaponifiable matter and fatty and resin acids.

The saponifiable acids are composed chiefly of fatty acids. The resin acid content is low, and it is likely that the small values found can be attributed to incomplete esterfication of the fatty acid fraction in the procedure.

The iodine number of the fatty acids suggests that they are largely oleic and linoleic acids. Evidently the nonfatty constituents have similar iodine numbers, because the values for fatty acids and total extract are approximately the same. The iodine number of the ether-soluble wood extractives decreased during seasoning from 154 to 102. In the case of ether-soluble bark extractives, the iodine number increased slightly from 106 to 112. It seems probable that the value of seasoning lies in a reduction of the amount of the extractives soluble in ether, rather than in the change in nature of the ether-soluble portion.

LITERATURE CITED

1. Isenberg, Irving H., in "Pulpwoods of United States and Canada," 1951.
2. Ritter, G. J., and Hossfeld, R. L., *Lake States Aspen Report*, No. 18, Dec., 1947, 19 pp.
3. Keller, E. L., and McGovern, J. N., *Tappi* 32: 400–405 (1949).
4. Wise, L. E., Murphy, M., and D'Addieco, A. A., *Paper Trade J.*, 122, No. 2: 35 (Jan. 10, 1946).
5. Snell, F. D., and Biffen, F. M., "Commercial Methods of Analysis," New York, McGraw-Hill, 1944.
6. Wolff, H., and Scholze, E., *Chem. Ztg.* 38: 369–70, 382–383 (1914).

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Chlorine Dioxide Generation by Reduction of Sodium Chlorate with Sulphur Dioxide

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A description of a pilot plant chlorine dioxide generator utilizing sulphur dioxide as a reducing agent for sodium chlorate in strong sulphuric acid is presented. This description includes design features, materials of construction, and operating characteristics. An attempt is made to explain the anomaly of the material balance efficiency being greater than the theoretical amount indicated by the chlorine dioxide-chlorine ratio. This explanation summarizes reasons for the belief that some chlorine monoxide is produced as the result of a side reaction.

In the past several years interest has been growing in the United States in the use of chlorine dioxide for the bleaching of pulp. A survey of the literature in this field, coupled with visual observations of German chlorine dioxide generating equipment, led to the belief that a generator of the type developed by I. G. Farben at Griesheim, Germany, offered significant advantages both in simplicity of construction and type of reaction utilized. Accordingly, a pilot plant generator was built and operated for the purpose of obtaining data that might interest and serve the pulp and paper industry.

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DESCRIPTION OF THE GRIESHEIM GENERATOR

During the early part of World War II, I. G. Farben constructed a pilot plant and semi-works plant for the manufacture of chlorine dioxide at Griesheim, Germany. These plants generated chlorine dioxide with the subsequent conversion of this material to sodium chlorite. The production capacities of the units were, respectively, 4 and 15 tons per month of 80% sodium chloride. The method of generation of chlorine dioxide used at Griesheim is of interest since it utilized relatively simple apparatus and a very concentrated solution mixture of sodium chlorate and sulphuric acid.

The reducing agent for this process was sulphur dioxide which was found to be highly effective because of its ability to instantaneously react with the chlorate and acid mixture.

The chlorine dioxide produced was of high relative purity containing a minimum of only 1 part of chlorine to 20 parts of chlorine dioxide. The generation apparatus was of a batch continuous type which required control only of the sulphur dioxide input in order to proportionately vary the chlorine dioxide output. In practice, the sulphur dioxide was diluted with air for the purpose of maintaining the chlorine dioxide concentration at less than 10% of the product gas volume.

Care must always be taken that chlorine dioxide be diluted with air or other inert gases. The recommended maximum partial pressure is said to be 0.1 atm. It was reported that the partial pressure of the chlorine dioxide in the Griesheim generator sometimes reached a maximum of 0.4 atm. However, no explosions were reported to have occurred at this concentration. The results obtained from the operation of the pilot plant and semi-works plant units at Griesheim were utilized for the design of a plant to have a capacity of 100 tons of 80% sodium chlorite per month. Completed units and drawings were observed by a technical group of the Technical Industrial Intelligence Branch of the U. S. Department of Commerce in 1946 (*5*).

DESCRIPTION OF THE EXPERIMENTAL GENERATOR

In 1948 an experimental generator of the Griesheim type was constructed and operated for the purpose of obtaining technical and operational information. This generator consisted of three vertical reactors manufactured of 4-ft. lengths of 4-in. pipe. The design capacity of the generator was 0.5 to 1.0 lb. of chlorine dioxide per hr.

In essence, the generator consists of three reactor vessels to which are added 35 to 42% sulphuric acid and an excess of sodium chlorate over that which would be soluble in the acid solution. Sulphur dioxide diluted with air is bubbled through this mixture, resulting in the formation of chlorine dioxide by the reduction of the chloric acid with the subsequent formation of sodium acid sulphate.

$$2NaClO_3 + 2H_2SO_4 \rightarrow 2HClO_3 + 2NaHSO_4$$
$$2HClO_3 + SO_2 \rightarrow 2ClO_2 + H_2SO_4$$
$$2NaClO_3 + H_2SO_4 + SO_2 \rightarrow 2ClO_2 + 2NaHSO_4$$

The first attempt to produce chlorine dioxide using a single reactor resulted in a product which was contaminated with about 20% by weight of chlorine based on the chlorine dioxide present. This contamination was thought to be the result of the reduction of chlorine dioxide by unreacted sulphur dioxide in the gas phase of the reactor and in the absorber liquor.

The results were similar to those reportedly obtained in Germany. In German practice, however, the product gases from the first reactor were conducted through a second reactor which would result in the decrease of the chlorine content to about 8%. When the product gases from the second reactor were passed through a third reactor, the chlorine content was reduced to 5% or less. The results obtained from the experimental generator closely followed the German results in that it was found that the use of three reactors in series would give a high quality chlorine dioxide.

The chlorate charge in the first reactor would become depleted as the reaction proceeded, with the result that the chlorate in the first reactor would eventually be completely consumed. When this occurred the reaction would automatically transfer to the second reactor.

Following the transfer of the reaction to the second reactor, the first reactor was drained, flushed out, and recharged. Then, through the manifolding system, it would be returned to the flow stream as the third reactor in the new sequence. During this out-of-service period of about 2 hr., no appreciable increase in the chlorine content of the product gas occurred.

In practice, it was found that the experimental reactors would hold sufficient chlorate and acid to allow operation for 8 to 10 hr. before it was necessary to recharge a reactor. During this time, the flow of chlorine dioxide was dependent only upon the rate of addition of sulphur dioxide properly diluted with air. It will be noted that the output of chlorine dioxide may be controlled by the sulphur dioxide input alone. At Griesheim a fourth reactor was employed so that it was possible to have a spare reactor in case repairs were required on one of the others.

The reaction of sulphur dioxide with a mixture of sulphuric acid and sodium chlorate is exothermic. Considerable heat is generated in the first reactor with a much smaller amount of heat being evolved in the second reactor. It is necessary, therefore, to employ cooling coils to remove this heat. The first reactor was operated at a maximum temperature of about 110°F. with the average temperature being 105 to 110°F. The second reactor was maintained at a temperature of slightly more than 80°F. A temperature of 122°F. has been reported to be in the danger region for the stability of chlorine dioxide and excessive temperatures might result in an explosion (*5*).

The temperatures of the first two reactors in the series should be maintained in excess of 80°F. since sodium-acid-sulphate is formed as a result of the reaction. This material forms large glassy crystals which plug the reactor at lower temperatures. Therefore, care was taken that the proper temperatures were maintained. Either hot or cold water could be circulated through the cooling coil in each reactor. It was found advantageous on initial start-up to heat the first reactor to about 80°F. and then to cool as soon as the sulphur dioxide was added and the reaction initiated. Heating and cooling of the experimental generator were controlled manually but automatic instrumentation would be desirable on a commercial unit.

It was found that the depletion of the chlorate charge in the first reactor could be recognized by the drop in temperature which resulted from the cessation of the reaction. If the sulphur dioxide were allowed to pass through the first reactor for a period of about one-half hour after it had been apparent that the reaction was slowing down, almost complete utilization of the sodium chlorate would result. In this case, up to 99.2% of the chlorate was found to have reacted. It was the German practice to use a sight glass in the discharge from the reactors for the purpose of determining completion of the reaction.

MATERIALS OF CONSTRUCTION

The materials of construction for a chlorine dioxide generator of this type are limited to a few materials. Although chlorine dioxide was reported to be not particularly corrosive to type 316 stainless steel and some of the other stainless steels, it was found that the mixture of reactants used with this generator was highly corrosive to metals and many other construction materials. It was determined, through substitutions of various portions of the generator, that the materials of construction for the portions of the generator in contact with the reactor charge and the evolved gases were limited to unplasticized Saran, unplasticized polyvinyl chloride,

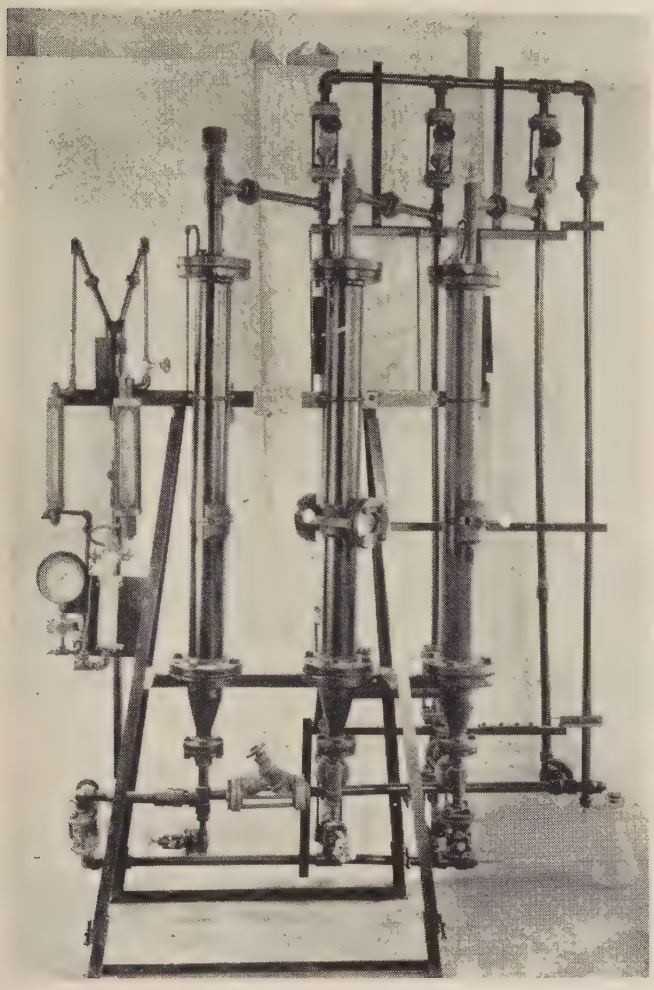

Fig. 1. Experimental generator

ceramics, or glass. Teflon, Kel-F, and Karbate may be satisfactory but were not tried.

Rubber undergoes a slow deterioration under the influence of chlorine dioxide and sulphur dioxide mixtures. The experimental generator was lined with rubber and although it was satisfactory during the period of experimentation, it was found to be somewhat eroded. It is planned to reline the reactors with unplasticized Saran or unplasticized polyvinyl chloride after complete deterioration of the rubber lining takes place. Hard rubber piping embrittled and lost its cohesive structure. Unplasticized Saran piping, on the other hand, showed no change in structure or evidence of wear.

Great difficulty was encountered in the choice of valves. A number of valves, composed of metals, plastics, and combinations thereof, were tried but they were found to be unsatisfactory owing to corrosion difficulties. Diaphragm-type valves, having plastic diaphragms, were found to be unsatisfactory because the reaction mixture leached out the plasticizer from the diaphragms with the result that they became corrugated and the valve would not close tightly.

The afore-mentioned difficulties with valves were solved through the use of Y-type globe valves fabricated entirely from unplasticized polyvinyl chloride. It was necessary to obtain these valves from England. It is understood that valves of this type are now manufactured in the United States. The plastic valves were found to be entirely suitable at the temperatures and pressures associated with the generator.

As a result of a number of experimental runs during which various materials of construction were tested, the generator was finally fabricated of steel reactors lined with Goodrich "Superflexite" rubber. Saran piping, polyvinyl chloride valves, and glass cooling coils and thermowells were also used. The German generators were made of the same materials with the exception that the reactors were lined with unplasticized polyvinyl chloride and the cooling coils were made of Heschotherm (silicon carbide).

The sulphur dioxide and air systems consisted of steel piping and valves. The chlorine dioxide was absorbed in a 10-ft. length of 2-in. glass pipe filled with $^1/_2$-in. Raschig rings. Dispersion of the sulphur dioxide in the bottom of the reactors was accomplished by means of Saran sparger tubes. The German generators employed a small bed of Raschig rings for this purpose.

CRITICAL DESIGN FEATURES

The experimental and German-type generators were found to have no particularly critical dimensions other than the diameter of the reactors and the cooling capacity. The horizontal cross-sectional area of the reactors should be sufficient to prevent "flooding." This area was found to be 1 sq. ft. of cross section for each 10 cu. ft. of air flow per min. One square foot of cross section should permit production of a maximum of about 10 lb. of chlorine dioxide per hr. Therefore, a generator of a capacity of 1 ton of chlorine dioxide per day should have reactors at least 3.25 ft. in diameter. The depth of the solutions in the reactors should be about 3 to 5 ft. with the greater depth being preferable because it allows more gas contact time. The greater depth also permits a longer operating time before the reactor must be recharged. The production rate of the generator is directly proportional to the sulphur dioxide feed.

Sufficient cooling surface must be provided to remove the heat generated by the reaction. The heat of reaction amounts to about 640 B.t.u. per lb. of chlorine dioxide produced. However, this value may vary considerably depending on the initial concentrations of the reactants. It is expected that in moderately sized units, internal cooling coils and a cooling jacket will be satisfactory for removal of heat. For very large units, it might be more suitable to circulate the reactor charge through an external heat exchanger.

Safety heads with frangible diaphragms should be provided to release the pressure in case of an explosion.

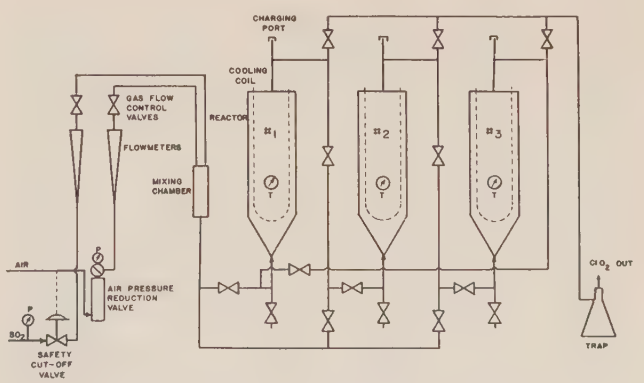

Fig. 2. Flow diagram of the experimental generator

A safety valve located at the trap (see Fig. 2) should also be used to vent off any excess pressure caused by a sudden increase in gas pressure. Generators of this type usually run at about 1.5 atm. absolute pressure. The slight pressure over atmospheric pressure is required to overcome the static head of the solutions.

RAW MATERIAL REQUIREMENTS

The experimental generator was usually charged with 3500 grams of sodium chlorate and 5 liters of 35% sulphuric acid. It was the German practice to use 42% sulphuric acid in equal volume. It was found, however, that satisfactory results could be produced using 35% acid. The maximum raw material requirements of the experimental and German generators per ton of chlorine dioxide are shown as follows:

	German	*Experimental*
Sodium chlorate	1.82	1.77
Sulphuric acid	1.45	1.1
Sulphur dioxide	0.82	0.71
Process water	2.0	2.05

It will be noted that the consumption of sulphur dioxide is about 50% greater than is theoretically required for the production of chlorine dioxide. This results from certain side reactions which take place. It is stated in the literature, and also by the Germans, that chlorine dioxide is produced in the first reactor and is subsequently reduced by the unreacted sulphur dioxide to chlorine. This reaction would require 5 moles of sulphur dioxide to produce 1 mole of chlorine (Cl_2). If it is assumed that the generator is producing 1 part of chlorine per 20 parts of chlorine dioxide, about 50% excess sulphur dioxide will be required. Undoubtedly all of the sulphur dioxide fed into the generator is reacted, since neither sulphur dioxide nor sulphate appears in the absorber liquor.

$$2NaClO_{3(s)} + H_2SO_{4(35\%)} + SO_{2(g)} \rightarrow 2ClO_{2(g)} + 2NaHSO_{4(s)} \quad \Delta H - 47.9 \text{ kcal.}$$

$$2ClO_{2(g)} + 4SO_{2(g)} + 4H_2O_{(l)} \rightarrow Cl_{2(g)} + 4H_2SO_{4(35\%)} \quad \Delta H - 309.8 \text{ kcal.}$$

$$2NaClO_{3(s)} + 5SO_{2(g)} + 4H_2O_{(l)} \rightarrow Cl_{2(g)} + 3H_2SO_{4(35\%)} + 2NaHSO_{4(s)} \quad \Delta H = -357.7 \text{ kcal.} \quad (8)$$

It is the writer's belief, however, that the afore-mentioned theory for the reaction in the generator is not entirely correct. There is a possibility that some chlorine monoxide is produced in the first reactor and is subsequently oxidized to chlorine dioxide in the second reactor.

$$2NaClO_{3(s)} + 4SO_{2(g)} + 3H_2O_{(l)} \rightarrow Cl_2O_{(g)} + 2NaHSO_{4(s)} + 2H_2SO_{4(35\%)} \quad \Delta H = -273.7 \text{ kcal.}$$

$$Cl_2O_{(g)} + 6NaClO_{3(s)} + 6H_2SO_{4(35\%)} \rightarrow 8ClO_{2(g)} + 3H_2O_{(l)} + 6NaHSO_{4(s)} \quad \Delta H = +82.1 \text{ kcal.}$$

$$8NaClO_{3(s)} + 4SO_{2(g)} + 4H_2SO_{4(35\%)} \rightarrow 8ClO_{2(g)} + 8NaHSO_{4(s)} \quad \Delta H = -191.6 \text{ kcal.} \quad (8)$$

This belief is based upon four factors:

1. Practically all of the heat of reaction was found to occur in the first reactor. If as much chlorine dioxide were being produced in the second reactor as is indicated by the chlorine to chlorine dioxide ratio of the product an appreciable amount of heat would be evolved. The production of chlorine monoxide from the chlorate is exothermic while the oxidation of chlorine monoxide to chlorine dioxide is endothermic as shown by the above equations. This above-mentioned side reaction would, therefore, agree with the qualitative heat balance observed during the runs.

2. The generator was operated using chlorine in place of sulphur dioxide with no appreciable amount of chlorine dioxide being produced. This would indicate that, should chlorine have been produced in the first reactor, it would not readily oxidize to chlorine dioxide in the second and third reactors.

3. Material balances with respect to the generator showed that generally 93% of the chlorate was converted to chlorine dioxide. Based on the 1 part of chlorine per 20 parts of chlorine dioxide found in the absorber liquor and the almost complete reaction of sodium chlorate in the reactor, it would be possible to get a maximum sodium chlorate conversion to chlorine dioxide of only 90%.

4. The analytical procedure used for chlorine in these experiments involved the oxidation of potassium iodide. Any chlorine monoxide which might have been present would have hydrolyzed to hypochlorous acid which would have appeared in the analysis as twice the amount of chlorine that was actually present in the chlorine monoxide.

$$Cl_2O + H_2O \rightarrow 2HOCl$$
$$2HOCl + 4KI \rightarrow 2I_2 + 2KCl + 2KOH$$

instead of

$$Cl_2 + 2KI \rightarrow 2KCl + I_2$$

It is very probable, therefore, that some of the chlorine reported as being present in the product was instead chlorine monoxide. The elimination of this analytical error would raise the theoretical sodium chloride efficiency from about 90 to 93% based on the residual chlorate left in the generator and the chlorine to chlorine dioxide ratio.

PRIOR ART

Since the process described in this paper was developed in Germany during World War II, no patents were obtained in the United States by I. G. Farben. It is believed that prior art relative to this process goes back to the Koln Rottweil patent of 1923 (*7*) and the Becher patent of 1933 (*1*). These patents refer to the use of chlorates in the presence of strong acid and a reducing agent for the generation of chlorine dioxide.

Cunningham patented the use of sulphur dioxide as a reducing agent in 1937 (*3*). He did not, however, make mention of the use of strongly acidic solutions of chlorates. Sulphur dioxide had been described as a reducing agent for chlorates in analytical procedures as far back as 1900 (*2*) and, in the form of bisulphites, had been used for the experimental production of chlorine dioxide in 1929 (*4*).

The Holst process, while somewhat similar to the I. G. Farben process in that it makes use of strong sulphuric acid and chlorate in an aqueous solution, utilizes reactors in parallel and differs from the I. G. Farben process in several respects (*6*).

CONCLUSION

It is believed that the use of a generator of this type for the commercial production of chlorine dioxide would offer advantages over other processes because of the relatively low acid requirement, improved chlorate efficiency, and the simplicity and ease of control of the

generation equipment. There is also the advantage that the sulphur dioxide, used as a reducing agent, either reacts instantaneously or remains in the gas phase and does not build up an appreciable concentration in the reactors. Therefore, there is no danger that the build-up of the reducing agent in the reactor solutions will result in an explosion.

While it was customary in Germany, and also during the tests of the pilot plant generator, to add solid sodium chlorate and dilute acid to the reactor, a more advantageous operation on a commercial scale might result from the addition of strong acid to a concentrated chlorate solution in the reactor. This would make possible the storage and handling of sodium chlorate as a solution which could be easily pumped to the reactors. The sodium chlorate could be dissolved from tank cars by warm water and held in a storage tank in solution until required.

LITERATURE CITED

1. Becher, Willy, German pat. 517,755 (Feb. 11, 1931).
2. Blattner, N., and Brasseur, J., *Chem. Z. 24:* 793 (1900).
3. Cummingham, George L., U. S. pat. 2,089,913 (Aug. 10, 1937).
4. Ferran, Jose U., *Quim. e ind. 6:* 219–221 (1929).
5. Gardiner, Wm. C., and Karr, E. H., Office Tech. Services Report, PB 33: 218 (1946).
6. Holst, Gustaf, *Paper Trade J. 128,* No. 1: 21–26 (1949).
7. Koln-Rottweil A. G., German pat. 378,289 (July 9, 1923).
8. Lange, Norbert A., "Handbook of Chemistry," 6th ed., Sandusky, Handbook Publishers, Inc., 1946.

Received June 23, 1953. Presented at the joint meeting of the Pacific Section of the Technical Association of the Pulp and Paper Industry and the Pacific Coast Division of the American Pulp and Paper Mill Superintendents Association, Gearhart, Ore., May 21–23, 1953.

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Permeation Through and Sorption of Organic Vapors by High Polymers

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Sorption data are reported for organic vapors in polymeric materials. From these data and previously published permeation data, diffusion constants are calculated. The sorption data are also analyzed from the point of view of current sorption and solution theory.

In our previous paper* we reported permeability constants P for the permeation of organic vapors through polyethylene (*1*). Here we have summarized a few measurements on the sorption of organic vapors by polymer films, including polyethylene, and have correlated some of the data with some previously reported permeation constants.

The sorption measurements were obtained by direct weighing of polymer samples hung from sensitive quartz spirals, in a vacuum, essentially as described by Simril and Smith (*2*). The vapor in question was admitted to the sample, in the vacuum, and the weight gain was computed from the increase in length of a calibrated spiral. Vapor pressures p were read directly with a mercury manometer and a cathetometer. The sorption data are present in Figs. 1 and 2 and in Table I as functions of relative vapor pressure x. The relative vapor pressure is defined as p/po where po is the vapor pressure of the pure liquid at a given temperature.

The nylon data, Fig. 1, at low relative vapor pressures of absorbate are probably best analyzed from the site-sorption point of view (*3*). It may be seen that the iotherms of nylon with water, methanol, and ethanol are nearly coincident at low relative vapor pressures. Application of the Brunauer, Emmett, and Teller equation (*4*) gives ca. 0.1 mole of vapor sorbed per 100 grams nylon (Du Pont 66-610-6 Nylon as 35.5-26.5-38%) as a "monolayer." It would seem that the fraction of peptide bonds in nylon available for sorption of water vapor (*5*) is also available for the alcohols. Incidentally, the sorption curve reported here for water-nylon is virtually identical to that reported elsewhere (*6*) at 25°. Although the curve at 25° has a slight S shape in going from low to high humidity, the curve is more nearly linear at low humidity at 40°. The S shape is apparently more pronounced (*7*) with 66-nylon, although the amount of water calculated for the monolayer is nearly the same in all three cases.

If one applies the Flory-Huggins solution theory (*3*) at high relative vapor pressures one obtains for μ, the semiempirical energy interaction factor, the value of 1.8 for the water-nylon system (between $x = 0.2$ and $x = 0.9$) and 0.8 to 1.0 for the nylon-ethanol system (between $x = 0.3$ and $x = 0.9$). These values are higher

Table I. Sorption of Vapors by Polymers

Polymer	*Vapor*	*Relative vapor pressure*	*Temperature, °C.*	*Moles per 100 g. polymer*
Polyvinyl alcohol	Ethanol	0–0.92	25	0
	Propionitrile	0–0.64	25	0
		0.80	25	0.40
		0.95	25	0.80
Polystyrene	Water	0.43	40	0.01
		0.65	40	0.02
		0.93	40	0.03
Polyvinyl chloride (Geon 101)	Water	0.60	25 or 40	0.06
		0.71	25 or 40	0.06
		0.91	25 or 40	0.08
		0.96	25 or 40	0.09
Saran	Water	0.70–0.9	25	0.01
Teflon	Water	0.8	25	0.01
		0.9	25	0.02
Polyethylene	Ethanol	0.2	25	0
	Methanol	0.2	25	0
Polystyrene	Water	0.43	40	0.01
		0.85	40	0.02
		0.93	40	0.03
		0.96	40	0.04

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* "The Permeation of Vapors Through Polyethylene," by Janice A. Cutler, E. Kaplan, A. D. McLaren, and H. Mark, *Tappi* 34: 404 (1951). Note that in our previous paper the word "water" should be deleted from the heading of column one in both Tables I and II.

Table II. Calculated Diffusion Constants for Vapors in Polymers

Polymer	*Vapor*	*P*	*S*	*D*	*References*
Polyethylene	Water	2×10^{-13} (25°)	0.04×10^{-4} (25°)	50×10^{-9}	(*1, 6*)
	Acetone	0.5×10^{-13} (25°)	0.07×10^{-4} (25°)	7×10^{-9}	(*1*)
	Propionitrile	1×10^{-13} (25°)	0.2×10^{-4} (25°)	5×10^{-9}	(*1*)
	Benzene	2×10^{-13} (25°)	0.7×10^{-4} (25°)	3×10^{-9}	(*1*)
Styrene	Water	48×10^{-13} (35°)	0.5×10^{-4} (35°)	100×10^{-9}	(*10*), this paper
Nylon	Water	156×10^{-13} (35°)	7×10^{-4} (35°)	22×10^{-9}	(*10*), this paper
	Ethanol	137×10^{-13} (35°)	3×10^{-4} (35°)	45×10^{-9}	(*10*), this paper
Polyvinyl chloride	Water	.....	4.5×10^{-4} (25°)	....	This paper

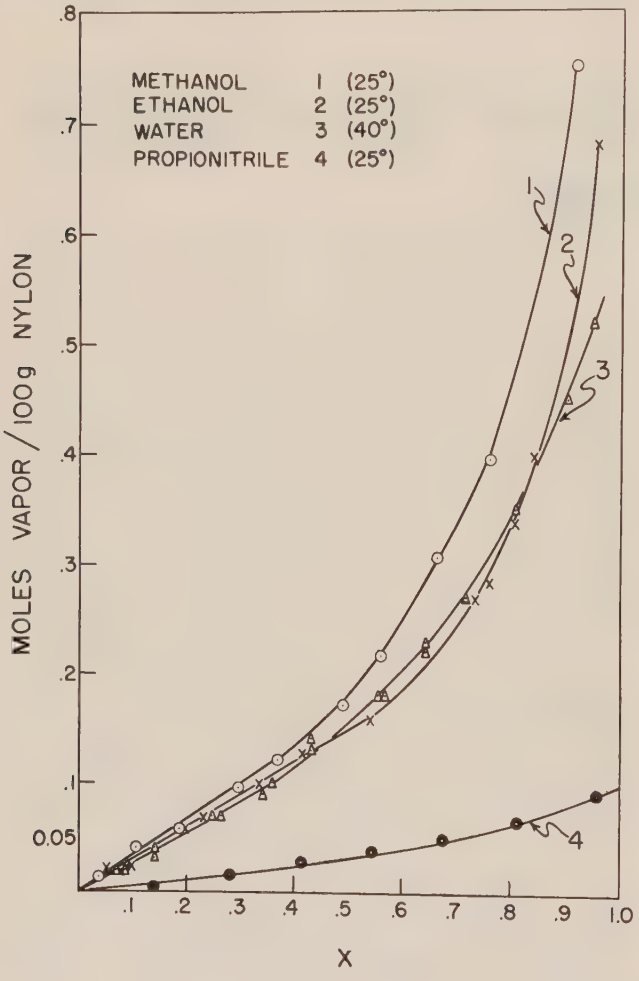

Fig. 1. Sorption of organic vapors and water by nylon

than $\mu_{crit.} = 0.5$ discussed by Huggins, indicating that as x approaches unity two phases should exist for either system (*8*). With polyethylene-benzene, Fig. 2, $\mu = 1.5$ to 1.8, also indicative of a tendency to separate into two phases as x equals unity, in conformance with actuality. It is interesting to note that only at temperatures in the neighborhood of 75°C. and higher are aromatic hydrocarbons capable of dissolving polyethylene. For solutions of polyethylene in xylene Muthana and Mark (*9*) report $\mu = 0.51$ which is just at the theoretical critical value. At room temperature it seems probable that benzene is dissolving only in the amorphous portions of polyethylene.

Simril and Hershberger (*10*) have recently published some permeability data for organic vapors through polymeric films which, along with ours, can be coupled with our sorption data to yield approximate diffusion constants D. The pertinent information is summarized in Table II. D is calculated from the well-known equation (*6, 11*).

$$D = P/S$$

where P = moles per square centimeter through centimeter thickness per second per centimeter (Hg) vapor-pressure differential and S = moles vapor sorbed per cubic centimeter of polymer per centimeter (Hg) pressure.

P is the permeability "constant" and S is the solubility coefficient. The equation can expectedly be strictly valid for the initial, more or less linear portion

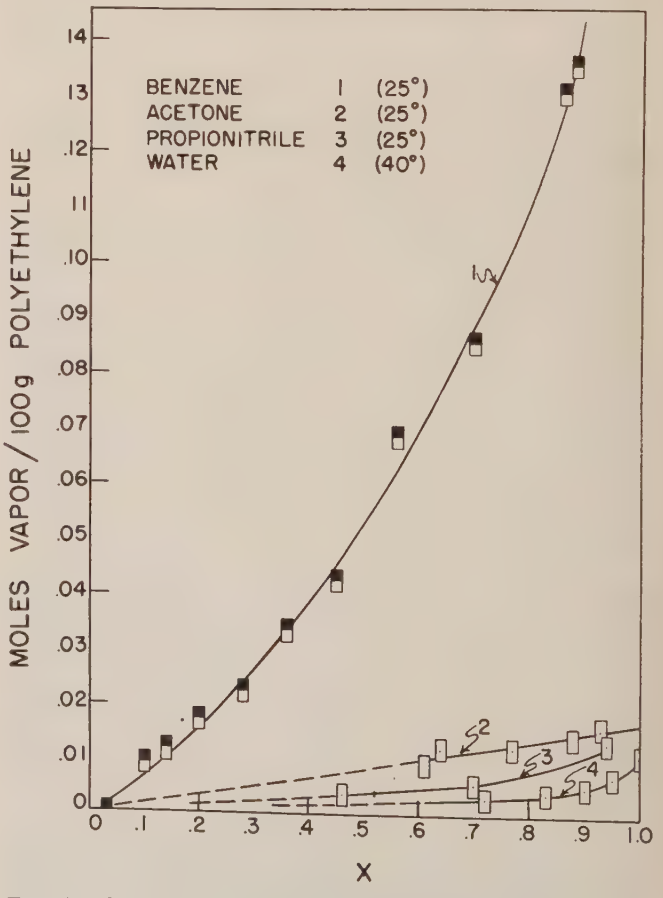

Fig. 2. Sorption of organic vapors and water by polyethylene

of the sorption isotherms, but will generally break down and be only approximate at high relative vapor pressures (*6*). The data used with the polyethylene systems are for low vapor pressures. Although Simril's permeation data with nylon are for 35°C., our sorption isotherm may be used to calculate solubility coefficients at 35° in view of the low-temperature dependence of sorption (*3*) and the small temperature differences involved; namely, 25 or 40°, as compared with 35°. With these approximations and others discussed previously (*2*), diffusion constants so calculated will have only relative significance, of course, but should be correct as to order of magnitude.

Whereas solubility coefficients S are proportional to the solubility of a vapor in a polymer, diffusion constants may be thought of as related to the openness of the structure, actual, or transient by thermal activation (*12*). Referring to Table II, one can see that the larger the molecule the smaller is the diffusion constant of the permeating vapor through polyethylene. It is seen from Table II, and the defining equation above, that the relative solubilities of the vapors acetone, propionitrile, and benzene are also of great importance in governing the relative rates of permeation, however. The greater the solubility the greater the permeation rate. (The permeation constants for the polyethylene systems in Table II are arbitrarily chosen (*1*) to correspond to ca. 10 mm. Hg vapor pressure.) The D and S values vary more from one system to another than do the corresponding P values. The higher solubility of water in polystyrene than in polyethylene seems to be mostly responsible for the higher permeation of water through polystyrene. It may be noted that P, S, and D constants for the nylon-water and nylon-ethanol systems are, respectively, surprisingly similar to each other.

Finally, it may be pointed out that our directly determined values of S for polyethylene and polyvinyl chloride are 0.1 cc. (per cc. polymer per cm. (Hg)) and 11 cc., respectively, whereas an indirect method, by permeation in a Barrer-type apparatus, gave 0.44 and 0.9, respectively (*12, 13*). A direct determination is probably capable of greater reliability. Some miscellaneous sorption data on polyvinyl alcohol are also included in Table I.

LITERATURE CITED

1. Cutler, J. A., Kaplan, E., McLaren, A. D., and Mark, H., *Tappi* 34: 404 (1951).
2. Simril, V. L., and Smith, S., *Ind. Eng. Chem.* 34: 226 (1942).
3. McLaren, A. D., and Rowen, J. W., *J. Polymer Sci.* 7: 289 (1951). Cutler, J. A., and McLaren, A. D., *J. Polymer Sci.* 3: 792 (1948).
4. Brunauer, S., Emmett, P. H., and Teller, E., *J. Am. Chem. Soc.* 60: 309 (1938).
5. Dole, M., and McLaren, A. D., *J. Am. Chem. Soc.* 69: 651 (1947).
6. Hauser, P. M., and McLaren, A. D., *Ind. Eng. Chem.* 40: 112 (1948).
7. Bull, H. B., *J. Am. Chem. Soc.* 66: 1499 (1944).
8. Huggins, M. L., *Ann. N. Y. Acad. Sci.* 44: 431 (1943).
9. Muthana, M. S., and Mark, H., *J. Polymer Sci.* 4: 527 (1949).
10. Simril, V. L., and Hershberger, A., *Modern Plastics* 27: 97 (June, 1950).
11. Barrer, R. M., "Diffusion in and Through Solids," New York, N. Y., Macmillan Co., 1941.
12. Doty, P. M., Aiken, W. H., and Mark, H., *Ind. Eng. Chem.* 16, 686 (1944).
13. Doty, P., *J. Chem. Phys.* 14: 244 (1946).

Received Aug. 10, 1952. This paper reports work done under contract with the Technical Command, Chemical Corps, U. S. Army.

Determination of Hydrogen Sulphide, Methyl Mercaptan, Dimethyl Sulphide and Disulphide in Kraft Pulp Mill Process Streams

V. F. FELICETTA, Q. P. PENISTON, and JOSEPH L. McCARTHY

Mass spectrometer examination of the volatile components in the condensate from kraft pulp digester blow gas has confirmed the presence of hydrogen sulphide, methyl mercaptan, dimethyl sulphide, and dimethyl disulphide, and has shown that corresponding ethyl compounds and other sulphur-containing derivatives are not present in substantial concentration. A relatively simple and rapid method for quantitative determination of each of the four above-named components in gas or condensate streams has been evolved and is set forth. The two acidic substances are batch-absorbed into aqueous sodium hydroxide solution while the two thio-ethers are simultaneously taken up in benzene. The liquid phases are then separated. Quantitative determination of hydrogen sulphide and methyl mercaptan in the alkaline aqueous solution is carried out using potentiometric titrations with silver nitrate. Quantitative determination of dimethyl sulphide and disulphide in the benzene solution is carried out by conducting bromate-bromide titrations of the components after having partly separated them by a single-stage batch distillation. Results obtained on known mixtures of substances are set forth. The method has given reasonably satisfactory analyses of two gas and two condensate process streams in a kraft pulp mill.

Those interested in kraft pulp production have expended much effort on the development of processes to avoid the discharge of odorous substances from kraft pulp mills. While this effort has resulted in important progress, the problem does not appear to be entirely solved because practical means for complete odor elimination do not seem to have been yet established. A major difficulty in locating odor sources and in testing performance of odor elimination processes has been the lack of accurate and facile analytical meth-

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ods. Thus the present work has been carried out to evolve improved methods for the quantitative determination of certain sulphur-containing compounds which are associated with the odors from kraft pulp mills. This paper reports methods which are believed to be more accurate, rapid, and duplicable by independent investigators than prior methods.

EXPERIMENTAL

Mass Spectrometer Experiments

Digester Blow Gas Condensate. A 150-ml. sample of condensate from kraft digester blow gas was acidified with 3 ml. of 2 normal sulphuric acid and was scrubbed with nitrogen at room temperature using a sintered glass gas diffuser. A nitrogen flow rate of 50 ml. per min. was maintained for 6 hr. Substances evolved were collected in a 50-ml. capacity "in-seal" trap cooled in liquid oxygen. Nitrogen was removed from the trap by evacuation at liquid oxygen temperature and the trap was then connected to the sampling line of the mass spectrometer (Type 21-103, manufactured by Consolidated Engineering Corp., Pasadena, Calif.). The sample was admitted to the instrument after warming to room temperature. Mass spectral peaks were determined for mass-charge ratios from 13 to 112 using standard operating conditions (Isatron temperature, 250°C.; ionizing voltage, 70 v.; ionizing current 10.5 microamp.).

The spectrum found was analyzed by the method of residuals using published spectra for hydrogen sulphide, methyl mercaptan, and carbon dioxide (*1*) and spectra found in these laboratories for dimethyl sulphide, dimethyl disulphide (Eastman Kodak Co.), oxygen, and nitrogen. Original peak heights and residuals remaining after subtractions for the above seven substances are shown in Table I.

To obtain a sample representative of the less volatile components, the trap, after sampling at room temperature, was cooled with solid carbon dioxide and evacuated for 2 min. to remove the more volatile components. The trap was then again connected to the instrument and again sampled after warming to room temperature. Data for the second analysis are also shown in Table I.

To demonstrate volatility and hence possibility of detection for ethyl mercaptan in the nitrogen scrubbing procedure, ethyl mercaptan was added to a sample of the digester blow gas condensate in amount by weight equal to one tenth of that found for methyl mercaptan (i.e., 20 mg. ethyl mercaptan per liter was added). The scrubbing, sampling, and analysis procedures were identical to those used to obtain the data in Table I. The peak height at a mass-charge ratio of 29 was 13.2 as compared with 3.3 previously obtained with the oxygen trap sample. Peak heights at other mass-charge ratios were essentially as shown in Table I.

Black Liquor Furnace Stack Gas Condensate. Attempts to concentrate sulphur-containing substances from the stack gas by condensation in a trap at liquid oxygen temperature gave unsatisfactory results due to the large amount of carbon dioxide contained. Attention was therefore shifted to the aqueous condensate obtainable from the gas by cooling to room temperature. Volatile substances were collected by acidification and nitrogen scrubbing as with the digester blow gas condensate.

Table I. Mass Spectra of Digester Blow Gas Condensate[a]

Mass-charge ratio	Oxygen trap		Solid CO_2 trap	
	Original peak heights	Residual peak heights[b]	Original peak heights	Residual peak heights[b]
13	...	...	32.0	1.8
14	47.2	7.4	67.2	2.0
15	94.5	20.5	144.9	6.5
16	60.2	5.0	4.7	0.0
17	4.8	4.8	3.0	3.0
18	3.7	3.5	5.6	5.3
22	8.8	8.8	...	...
22.5	1.4	1.0	...	...
23	2.6	1.2	...	...
23.5	1.4	0.7	...	...
24	3.9	1.6	0.7	0.1
25	...	...	1.1	0.1
26	1.8	0.4	4.9	1.1
27	33.9	0.8	95.7	4.9
28	75.7	0.0	17.5	0.0
29	3.3	1.2	8.0	3.2
30	1.9	1.9	0.8	0.8
32	183.0	0.0	81.1	3.0
33	162.0	22.7	59.7	3.4
34	288.0	0.0	110.4	0.0
35	64.1	2.5	150.3	1.2
36	16.3	3.8	7.5	1.4
37	2.9	0.5	7.2	0.7
38	1.4	1.4	1.4	1.3
39	...	...	4.2	4.2
41	...	...	3.6	3.6
42	...	...	1.1	1.1
43	1.9	1.9	11.1	11.1
44	519.0	0.0	52.2	8.2
45	376.0	90.1	441.0	9.8
46	135.0	19.0	258.0	3.8
47	587.0	63.7	548.0	4.8
48	324.0	0.0	77.1	0.0
49	31.6	2.3	29.0	0.4
50	14.3	—0.2	3.4	0.3
51	...	...	1.2	1.0
53	...	...	1.5	1.5
56	1.2	0.0	3.4	0.1
57	5.2	0.5	14.3	1.2
58	6.1	0.5	17.4	1.9
59	4.9	0.0	14.1	0.4
60	1.1	0.3	2.8	0.1
61	51.0	—0.6	156.0	0.3
62	130.0	0.0	354.0	0.0
63	5.9	—1.0	17.3	—0.2
64	7.2	—0.1	35.5	—0.6
65	...	...	1.9	0.6
66	...	...	2.1	0.2
73	...	...	1.0	1.0
76	2.1	1.6	2.8	0.1
77	...	...	2.3	1.4
78	...	...	5.2	0.4
79	8.4	1.2	87.6	—2.2
80	3.6	0.0	4.8	1.8
81	2.3	0.0	8.9	1.2
82	3.5	0.4	2.0	2.0
88	...	...	1.3	1.3
91	...	...	1.8	1.7
92	...	...	1.8	1.8
93	...	...	7.2	5.7
94	11.2	3.6	140.4	0.0
95	0.4	2.3	5.3	0.1
96	1.4	3.5	12.9	0.4

[a] Values with original peak heights below 1.0 are not listed
[b] After subtraction of spectra for N_2, O_2, CO_2, H_2S, CH_3SH, $(CH_3)_2S$, and $(CH_3)_2S_2$.

One mass spectrometer sample was drawn at room temperature after removing most of the nitrogen by vacuum evaporation at liquid oxygen temperature. Then another sample was drawn at about 50°C. after further vacuum evaporation at solid carbon dioxide temperature. The first sample showed major peaks at mass-charge ratios for nitrogen, carbon dioxide, and oxygen with some sulphur dioxide. Hydrogen sulphide was not detected and since it is known to be an important component of the stack gas (see Table II), it may have been removed by reaction with sulphur dioxide.

Dimethyl sulphide and dimethyl disulphide were found in approximately equal trace quantities.

The sample drawn after pumping at solid carbon dioxide temperature showed only trace amounts of all components except water. The peaks for dimethyl di-

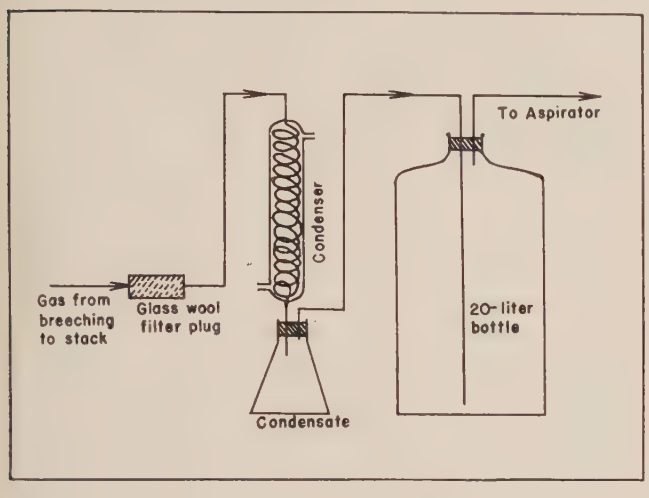


Fig. 1. Gas sampling apparatus

sulphide were approximately doubled by pumping at carbon dioxide versus liquid oxygen temperature. Again, no peaks were found at mass-charge ratios indicative of ethyl compounds.

Analyses of Kraft Pulp Mill Process Streams

Black Liquor Furnace Stack Gas. Sampling: The apparatus used to obtain gas samples for the present investigation is sketched in Fig. 1. The line from breeching used for obtaining samples of gas going to the stack should be sufficiently insulated, and the flow rate through the line should be sufficiently high so that the temperature at the inlet to the condenser is above the dew point of the gas (about 165°F. for present samples).

To collect a sample, it is first necessary to draw at least 100 liters of gas through the apparatus to flush out air; the sample is then available in the 20-liter bottle. Alternatively, air can be pumped out of the sample bottles and then the stack gas can be permitted to fill the bottles up to atmospheric pressure. If more than one sample is desired for duplicate analyses, two or more 20-liter bottles can be connected in series.

Absorption and Separation of H_2S and CH_3SH from $(CH_3)_2S$ and $(CH_3)_2S_2$; For absorption and separation of acidic from nonacidic components, 200 ml. of 1.5 *N* NaOH solution and 100 ml. of C.P. benzene are added to the 20 liters of gas comprising the sample. Addition of the liquids is made through a separatory funnel attached through one of the holes in the stopper of the bottle. Air pressure is used to force the absorbing liquids into the bottle thus leaving the bottle under a slight positive pressure. The liter bottle is turned end over end for 10 min. by hand, or is machine-shaken, to absorb sulphur-containing substances from the gaseous phase. After absorption is nearly completed, the pressure is relieved through the separatory funnel connection. Then exactly 100 grams of crushed ice are added, and the bottle is restoppered and shaken until ice has melted and absorption presumably has been completed. Immediately, the liquid in the 20-liter bottle is poured into a separatory funnel, and the phases are allowed to separate and then drawn off. Separation of phases has required only a few seconds. The acidic substances, hydrogen sulphide and methyl mercaptan, appear as sodium salts in the aqueous alkaline solution. The nonacidic thio-ethers, dimethyl sulphide and dimethyl disulphide are present in the benzene.

Determination of Hydrogen Sulphide and Methyl Mercaptan: For this determination, a potentiometric titration has been found entirely satisfactory. The method used is essentially that reported by Tamele *et al.* (*2*) in 1941 and by Lykken and Tuemmler in 1942 (*3*).

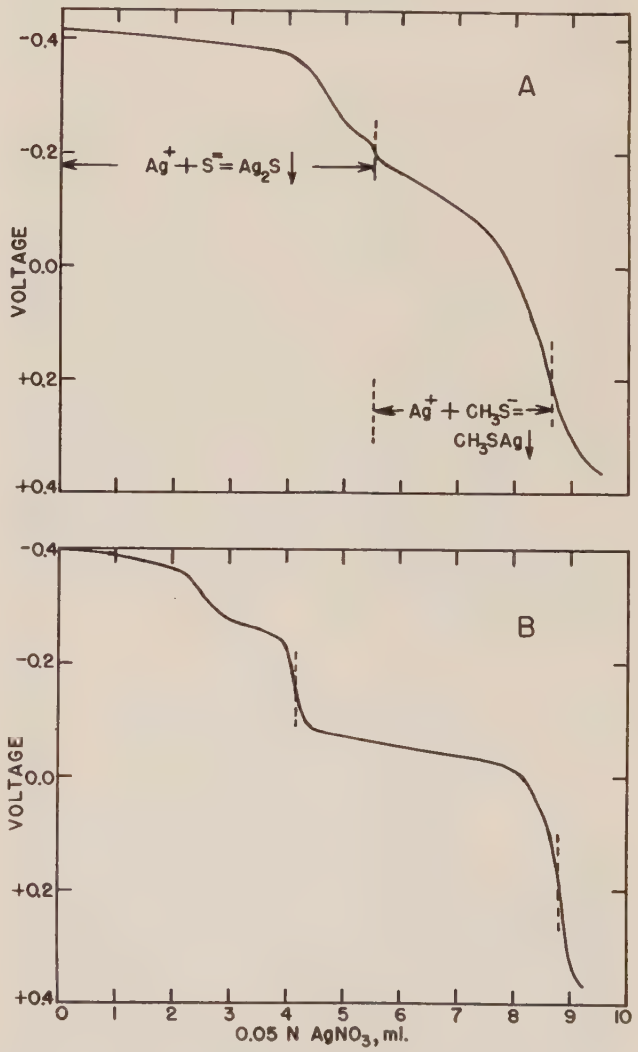


Fig. 2. Potentiometric titrations of sodium sulphide and methyl mercaptide:

A. known mixture; *B.* digester blow gas condensate.

From the alkaline aqueous solution obtained by the absorption step is taken an aliquot of about 250 ml. which is placed in a 400-ml. beaker and made 0.1 *N* in ammonium hydroxide to prevent precipitation of silver oxide during the determination. The liquid is

then titrated with 0.05 N silver nitrate solution and progress of the titration is followed using a pH meter equipped with a silver-silver sulphide electrode and also a glass electrode specially designed for use under highly alkaline conditions. The meter is initially standardized against a known buffer solution with the glass electrode and a calomel electrode. Increments of silver nitrate solution are added with stirring and meter readings on either the pH or voltage scale are recorded after each addition. A meter reading is recorded when it does not change by more than 10 millivolts in 10 sec. If the titration is performed fairly rapidly no appreciable oxidation of mercaptan occurs in the open beaker. End points are taken where the change in meter reading per unit volume of added silver nitrate solution is a maximum. However it is to be noted that two inflection points are sometimes obtained in the titration of sulphide as shown in Figs. 2A and 2B, and that experiments with known compounds indicate that the second inflection point should be used in calculation of sulphide content.

When using pH indications, the first reading may be off the scale but this is of no consequence since the meter readings for the end points are on the scale. Hydrogen sulphide and its sodium salt give rise to the first end point at a meter reading between 2 and 5 on the pH scale, whereas methyl mercaptan and its sodium salt cause the second end point between 8 and 10. Meter readings are dependent upon the condition of the silver-silver sulphide electrode. A practice of wiping the tip of this electrode with a cloth and treating with a solution of sodium sulphide after each determination has been followed in this work. When the voltage scale is used, the sulphide end point appears at about -0.2 v. and the mercaptan end point at $+0.2$ v. However, the end points are usually indicated by a very obvious inflection point in the voltage-volume plots and not by definite, established potentials (*2*). Typical titration curves are shown in Fig. 2 for known mixtures and for digester blow gas samples.

Reactions and calculations are as follows:

$$2Ag^+ + S = \rightarrow Ag_2S\downarrow \quad (1)$$

$$\text{mg. } H_2S = (\text{ml. } AgNO_3 \text{ to } H_2S \text{ end point})(300/250)(N \text{ of } AgNO_3)(17.04) \quad (2)$$

$$Ag^+ + CH_3SH \rightarrow AgSCH_3\downarrow + H^+ \quad (3)$$

$$\text{mg. } CH_3SH = (\text{ml. } AgNO_3 \text{ to } CH_3SH \text{ end point from } H_2S \text{ end point})(300/250)(N \text{ of } AgNO_3)(48.11) \quad (4)$$

Separation of Dimethyl Sulphide from Dimethyl Disulphide: To permit individual determination of dimethyl sulphide and disulphide obtained in benzene solution by the method described above, a partial separation is carried out by distillation. A 90-ml. aliquot of the benzene solution is placed in a 100-ml. round bottom flask containing two small pieces of porous plate. The flask is connected to a 6 to 8-in. condenser by a ground glass joint. The receiver from the condenser is marked to indicate a volume of 60 ml. The condenser is equipped with a capillary breather near the receiver end (see Fig. 3). A boiling water bath is placed to cover the distilling flask and the distillation is allowed to proceed until exactly 60 ml. of distillate is collected which usually requires 7 to 12 min. This distillate contains nearly all the dimethyl sulphide but only about 40% of the dimethyl disulphide.

Determination of Dimethyl Sulphide and Dimethyl Disulphide: Both dimethyl sulphide and dimethyl disulphide are determined by the bromate-bromide titration method of Siggia and Edsberg (*4*). The benzene distillate solution is transfered to a 250-ml. glass-stoppered Erlenmeyer flask using 40 ml. of glacial acetic acid. To the solution in the flask is then added 10 ml. of water, 25 ml. of concentrated hydrochloric acid, and 2 drops of 0.2% solution of Brilliant Ponceau 5 R. The flask is stoppered, the mixture is warmed to about 40°C. in a hot water bath and then titrated with standardized 0.05 N bromate-bromide until the color turns from pink to a yellowish orange. The bromate-bromide solution is prepared as recommended by Siggia and Edsberg (*4*). During titration, the solution is shaken vigorously. When the color of the solution changes, an additional drop of indicator is added because the indicator reacts with bromine and fades at a rate which is comparable with the rates of reaction of dimethyl sulphide and disulphide with bromine. The titration can be done rapidly and the indicator change is easily discernible with a little experience. A blank titration with all reagents except the organic sulphides is also conducted. The blank usually amounts to about 0.1 to 0.2 ml. of 0.05 N bromate-bromide. The titration is also carried out on the residual benzene solution which was not distilled.

Reactions are as follows:

$$(CH_3)_2S + Br_2 \rightarrow (CH_3)_2SBr_2 \xrightarrow{H_2O} (CH_3)_2SO + 2HBr \quad (5)$$

$$CH_3SSCH_3 + 5Br_2 + 4H_2O \rightarrow 2CH_3SO_2Br + 8HBr \quad (6)$$

Solute remaining in the undistilled benzene solution is calculated to be entirely $(CH_3)_2S_2$, and solutes in the distillate are calculated to be 40% of the $(CH_3)_2S_2$ in the system and the remainder to be $(CH_3)_2S$ as follows:

$$\text{mg. } (CH_3)_2S = \left\{\left[\begin{matrix}\text{ml. reagent-blank}\\ \text{for condensate}\end{matrix}\right] - \left[\left(\begin{matrix}\text{ml. reagent-blank}\\ \text{for residue}\end{matrix}\right)\left(\frac{40}{60}\right)\right]\right\}\left\{\left(\frac{100}{90}\right)\left(\begin{matrix}N \text{ of}\\ \text{reagent}\end{matrix}\right)(31.09)\right\} \quad (7)$$

$$\text{mg. } (CH_3)_2S_2 = \left\{\begin{matrix}\text{ml. reagent-blank}\\ \text{for residue}\end{matrix}\right\}\left(\frac{100}{60}\right)\left(\frac{100}{90}\right)\left(\begin{matrix}N \text{ of}\\ \text{reagent}\end{matrix}\right)(9.42) \quad (8)$$

Results of analyses of stack gas from recovery furnaces by the methods described above are given in Table II. With a 20-liter sample of gas, the lower limits of hydrogen sulphide or methyl mercaptan concentration for satisfactory analysis are about 10 and 20 p.p.m., respectively. For dimethyl sulphide and dimethyl disulphide, the lower limits are about 20 and 10 p.p.m., respectively. These latter limits give a titration value which is 10 times that of the usual blank titration.

Digester Relief Gas. The gas from digesters being relieved is under pressure so a sample was collected simply by permitting the gas to flow through 20-liter bottles placed in series. The samples were analyzed using procedures identical to those described for stack gas from the recovery furnaces except that smaller aliquots of both the alkaline aqueous solution and the benzene solution were used because sulphur-containing substances were present in much higher concentration. Results are given in Table II.

Digester Blow Gas Condensate. Samples consisting of aqueous solutions, such as condensate from digester

blow gas were analyzed directly since the absorption technique was unnecessary. Hydrogen sulphide and mercaptan were determined on a sample of 50 to 100 ml. wnich had been made up to 300 ml. and then adjusted to 1.0 *N* with sodium hydroxide solution. Ammonium hydroxide was added to make 0.1 *N* concentration and the potentiometric titration was conducted as usual with 0.05 *N* silver nitrate solution.

Table II. Analysis of Kraft Mill Process Streams

Stream	*Substance* H_2S	CH_3SH	$(CH_3)_2S$	$(CH_3)_2S_2$
Stack gas[a]				
Sample 1, 1/9/52	493	42	..	2[c]
Sample 2, 3/11/52	759	68	..	5[c]
Sample 3, 3/11/52	534	64	..	2[c]
Digester relief gas[a]				
Sample 1, 3/11/52	131	5240	7350	4095
Sample 2, 3/11/52	138	4880	7000	3870
Digester blow gas condensate[b]				
Sample 1, 1/9/52	71.7	232	171	125
Sample 2, 1/9/52	73.9	206	184	126
Sample 3, 1/9/52	71.7	227	187	128
Sample 4, 3/11/52	32.0	89.0	116	207
Sample 5, 3/11/52	33.6	84.0	120	212
Evaporator condensate[b]				
Sample 1, 3/11/52	61.0	27.0	..	11[c]
Sample 2, 3/11/52	61.0	29.0	..	11[c]

[a] Concentrations in parts per million by volume.
[b] Concentrations in milligrams per liter.
[c] Calculated to be entirely $(CH_3)_2S_2$ which may or may not include some $(CH_3)_2S$. These values are questionable because the component concentrations are considerably below those necessary for accurate analyses. Unknown and unaccounted for nonvolatile unsaturated material remaining after the distillation step was here found to have consumed as much or more reagent than the $(CH_3)_2S_2$.

For determination of dimethyl sulphide and disulphide, a 50-ml. sample of condensate has generally been found adequate. The sample, together with 100 ml. of 1.5 *N* sodium hydroxide solution and 100 ml. of benzene, is placed in a separatory funnel and thoroughly shaken to extract organic sulphides and disulphides into the benzene phase. The separated benzene solution is back extracted with 50 ml. of 1.0 *N* sodium hydroxide solution and the residual benzene phase is subjected to the distillation procedure as described above.

Results secured on condensates from digester blow gases taken at two different times are presented in Table II. Using a 50-ml. sample of condensate or other liquid samples, the lower limits of hydrogen sulphide and methyl mercaptan concentration for reasonably accurate analyses are 5 and 20 mg. per liter, respectively. The lower limits for methyl sulphide and methyl disulphide are about 50 and 15 mg. per liter, respectively.

Black Liquor Evaporator Condensate. This stream of condensate was analyzed by the same methods as were used for analysis of the digester blow gas condensate. The methods were found to function satisfactorily using a 100-ml. aliquot of the sample for potentiometric titration, and a 500-ml. aliquot for bromate-bromide titration. Results are given in Table II.

DISCUSSION

Identity of Sulphur-Containing Substances

In the present study, the mass spectrometer has been used to examine kraft mill process streams for the presence of certain sulphur-containing substances suspected as the principal sources of objectionable odors. The substances of interest were four, i.e., hydrogen sulphide, methyl mercaptan, dimethyl sulphide, and dimethyl disulphide. P. Klason (*5*) in 1908 established the presence of methyl mercaptan and dimethyl sulphide in sulphate digester blow gas, and suggested a mechanism for their formation from methyl ether groups of lignin during the pulping process. It was also of importance to determine whether there might be present other sulphur-containing substances (such as similar ethyl compounds possibly arising from sugar degradation in the strongly alkaline kraft pulping liquors) which might cause confusion or errors in interpretation of analytical data. However, the mass spectra obtained (Table I) are believed to show conclusively that the above-named four substances are present in the condensate from digester relief gas, and that ethyl or other unexpected volatile derivatives are not present in amounts significant with respect to the odor problem. Similar conclusions apply to the gas flowing from black liquor furnaces to the stack.

In a mass spectrometer, the position of a peak is determined by the ratio of mass to electrical charge on a molecular or atomic particle, and the height of a peak reflects the relative frequency of occurrence of a particle having a given mass to charge ratio. If one electrical charge is acquired by a particular molecule such as hydrogen sulphide with molecular weight of 34, then the mass-charge ratio of the resultant particle will be 34. Since this simple event occurs frequently, a high peak at 34 mass-charge ratio is expected when hydrogen sulphide is present (see Table I). Other peaks will also occur in the mass spectra of a pure substance and these may arise from presence of fragments fissioned from the parent molecule, from presence of isotopes, and from various electrical charge situations. The mass spectra of many pure compounds have now been determined and published, and the mass spectrometer is in wide use in the petroleum industry because of the great utility of this tool in both qualitative and quantitative analysis.

Table I gives mass spectra for the mixture of volatile substances present in "oxygen-trap" and in "solid CO_2 trap" condensate from digester blow gas. By reference to spectra previously obtained on pure substances, the major peaks experimentally observed at mass-charge ratios of 14, 15, 16, 27, 28, 32, 33, 34, 35, 44, 45, 46, 47, 48, 61, 62, 79, and 94 can be attributed to the presence of the following particles; N, CH_3, O, ?, N_2, O_2, or S, HS, H_2S, ?, CO_2, CSH, CH_2S, CH_3S, CH_3SH, CH_3SCH_2, CH_3SCH_3, CH_3SS, and CH_3SSCH_3, respectively.

The observed mass spectra were treated by assuming that N_2, O_2, CO_2, H_2S, CH_3SH, $(CH_3)_2S$, and $(CH_3)_2S_2$ were present in substantial amounts, and by subtracting the spectra known for each of these components (*1*) from the observed spectra. For each named substance, a particular mass-charge ratio was considered at which a substantial peak was evident for this substance but not for any of the other named substances. The peak heights in the entire known spectrum for this substance were adjusted proportionally so that the peak height at the particular mass-charge ratio was equal to the peak height observed in the condensate sample. Then these adjusted peak heights characteristic of the substance were subtracted from the peak heights observed from

the condensate sample to leave a "residual spectrum." In a similar manner the adjusted spectrum for each of the seven substances assumed present was subtracted from the observed spectrum finally to leave the spectra of "Residual Peak Heights" shown in Table I.

Now if N_2, O_2, CO_2, H_2S, CH_3SH, $(CH_3)_2S$, and $(CH_3)_2S_2$ were the only substances present, all residual peak heights should be substantially zero. That this is nearly the case indicates the validity of the assumption that the above-named substances are the major components of the system. The few important residuals unaccounted for by these substances occur at mass charge ratios of 15, 33, 43, 45, 46, and 47. The 15 peak is probably due to presence of CH_3 whereas the

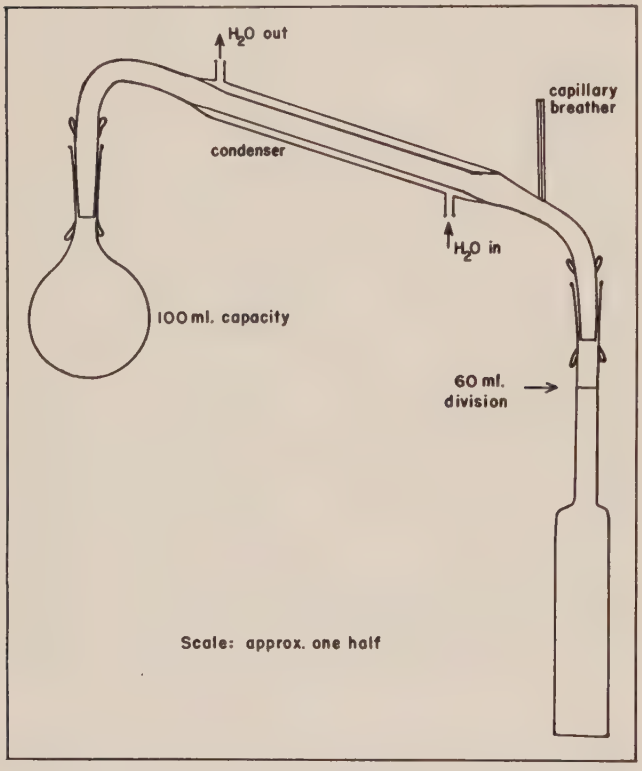


Fig. 3. Apparatus for batch distillations of benzene solution of dimethyl sulphide and disulphide

others remain incompletely explained. Methyl ether could originate from methyl groups in wood by a mechanism similar to that by which methyl sulphide originates but it was not present in the sample studied since a characteristic peak at mass-charge ratio of 29 was not observed. By the same type of examination it was established (*1*) that CS_2, COS, CHCH, HCHO, CH_3CHO, HCOOH, and CH_3COOH were not present in observable concentrations. Mass spectra reported in the literature (*1*) on ethyl mercaptan showed that major peaks occur at mass-charge ratios of 27, 28, 29, 47, and 62. The fact that peak heights at mass-charge ratio 29 are small shows that ethyl derivatives are not important components of the samples.

Mass spectrometer study of stack gas and condensate there from was also undertaken because formation of sulphur compounds of interest might take place by pyrolysis in the furnace or cascade evaporators as well as during the pulping process. Investigation of these process streams presented some difficulties because of the low concentrations at which sulphur compounds were present. However, the mass spectrometer data in conjunction with other analyses obtained indicate that hydrogen sulphide is the most important sulphur-containing component, methyl mercaptan is of secondary importance, and dimethyl sulphide and disulphide are of minor significance. Ethyl derivatives were not observed.

Determination of Sulphur-Containing Substances

After mass spectrometer confirmation had been obtained of the presence of hydrogen sulphide, methyl mercaptan, dimethyl sulphide, and dimethyl disulphide as the important volatile sulphur-containing components in kraft pulp mill process streams, it was possible with confidence to select and develop analytical methods by which these substances best could be determined quantitatively and expediently. Thus prior methods have been considered and improved, some new techniques have been evolved, and the methods have been tested on kraft pulp mill process streams with results which are given in Table II. The procedures recommended for use are given in detail in the Experimental Section and will require only brief comment here.

The step of collection of a gas sample has now been separated from the steps of absorption of components from gas to liquid phase with the result that the slow rate of absorption no longer controls the rate at which samples can be taken. Gas is simply flowed through a large bottle until the originally contained air is nearly completely displaced; the stoppered-off bottle then comprises the sample. In sampling black liquor furnace stack gas (which in the present case was at about 200°F. dry bulb and 160°F. wet bulb temperature) condensate separation should be avoided by use of short insulated sampling lines and high flow rates, because salt cake and sodium carbonate fume in the gas may dissolve in condensed liquid to make an alkaline solution which can remove hydrogen sulphide and methyl mercaptan from the gas sample.

The absorption of known amounts of sulphur-containing substances separately and in mixtures, was at first conducted using conventional absorption trains (*6*). However, such procedures were found unsatisfactory because recovery and separation of components were incomplete to a degree which varied widely with the type of absorption apparatus and gas flow rates used, and because the time required for absorption of an adequate gas sample seemed to be as much as 1 or 2 hr. These difficulties were avoided by collecting a gas sample in a bottle as described above, and then adding sodium hydroxide solution with benzene and shaking the bottle to accomplish batch absorption to equilibrium of the sulphur-containing substances into these liquids. A class separation of sulphur derivatives is simultaneously achieved in that the acidic substances, hydrogen sulphide and methyl mercaptan, dissolve in the aqueous sodium hydroxide solution, while the non-acidic constituents, dimethyl sulphide and dimethyl disulphide, dissolve in the benzene. For samples which are aqueous solutions, such as condensate liq-

uors, it is only necessary to adjust the alkalinity and to add benzene and then proceed as usual. Studies on the over-all absorption and partition of known amounts of these compounds, separately and in mixtures, have been carried out under the recommended conditions. Some

Table III. Over-All Absorption and Partition of Sulphur-Containing Known Compounds

Experiment	Added: Substance	Added: Amount, mg./20 l.	Absorption method	Phase and volume titrated,[c] ml.	Per cent of added component found
1	$(CH_3)_2S$	27	[a]	B 43	80.1
2	$(CH_3)_2S$	25.2	[a]	B 44	80.1
				B 46	79.5
3	$(CH_3)_2S$	18.3	[a]	B 25	98.4
				B 25	98.4
				B 25	97.5
4	CH_3SH	21.8	[b]	W125	91.1
				W104	88.4
5[d]	Na_2S	24.5	[b]	W100	86.5
				W100	95.5
	CH_3SH	13.9	[b]	W100	78.4
				W100	80.6
	$(CH_3)_2S$	14.0	[b]	B 33.6	96.1
	$(CH_3)_2S_2$	17.1	[b]	B 38.8	95.4

[a] Five minutes' total shaking time without using crushed ice.
[b] Ten minutes' shaking time with crushed ice added.
[c] "W" = water phase; "B" = benzene phase.
[d] All four components were present in the mixture analyzed but $(CH_3)_2S$ and $(CH_3)_2S_2$ were not determined separately.

of the results are given in Table III and it is concluded that absorption and partition of hydrogen sulphide and methyl mercaptan into the alkaline aqueous phase may be 85 to 95% complete, while absorption and partition of dimethyl sulphide and disulphide into the benzene phase may be 95% complete or better. The degree of recovery at equilibrium is influenced by the relative volumes of gas and liquid phases, by the temperature, and by the concentrations at which the various components are present.

Quantitative determination of hydrogen sulphide and methyl mercaptan in the alkaline aqueous solution was carried out using a potentiometric titration method

Table IV. Potentiometric Analyses of Known Solutions of Sulphides and Mercaptans

Substance	Amount added[a], mg.	Amount found, mg.	Found, %
CH_3SH	40.2	36.6	91.0
	3.89	3.66	94.1
	4.00	3.99	99.8
	0.648	0.543	84.1
	7.71	7.61	98.8
Na_2S	39.1	35.8	91.5
	3.91	3.19	81.6
	12.5	12.0	96.2
Na_2S + CH_3SH	39.1 + 43.9	40.0 + 40.9	102.0 + 93.3
Na_2S + CH_3SH	11.0, 11.0 + 8.03, 8.03	10.6, 10.4 + 7.77, 8.00	96.4, 94.6 + 96.9, 99.6

[a] Mercaptan weighed in sealed ampoules, sodium sulphide assayed by an independent method before use.

reported by Tamele, *et al.*, and by Lykken and Tuemmler. Titration curves for known mixtures and for digester blow gas components are shown in Fig. 2. Potentiometric analyses obtained on known solutions of sulphides and mercaptans are given in Table IV to show that moderately good accounting can be obtained for known amounts of the substances of interest.

Quantitative determination of dimethyl sulphide and dimethyl disulphide in the benzene phase was carried out using the procedure of Siggia and Edsberg, together with a distillation technique. The method is useful provided that hydrogen sulphide and methyl mercaptan are absent. We did not obtain satisfactory results us-

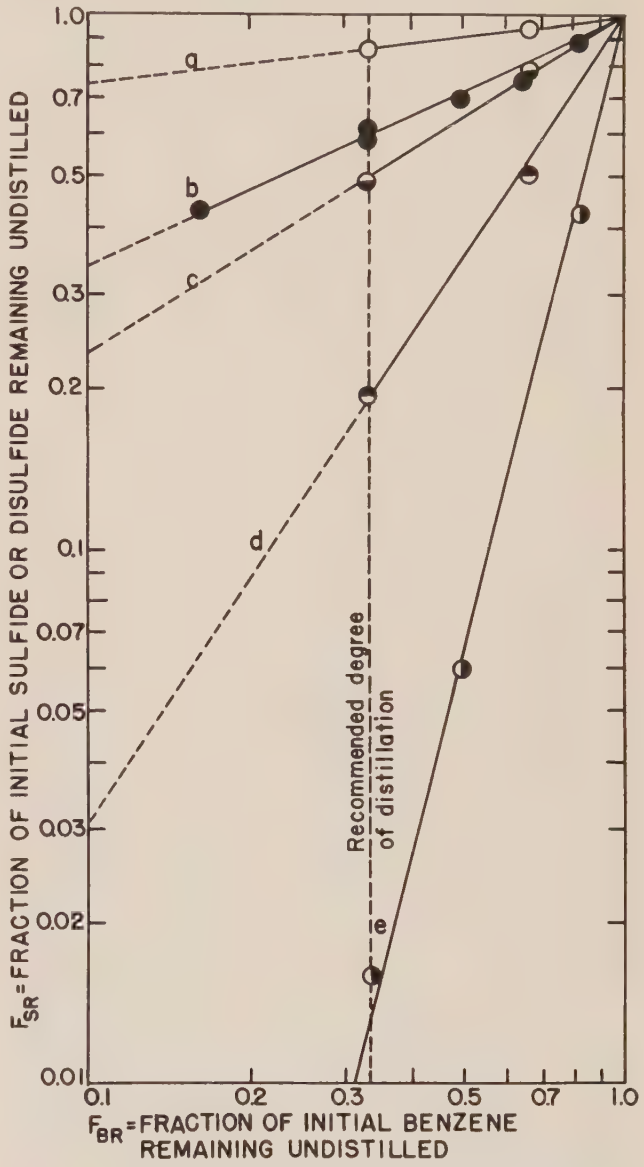


Fig. 4. Batch distillation of methyl and ethyl sulphides and disulphides in benzene solution:

(*a*) diethyl disulphide, (*b*) dimethyl disulphide, (*c*) diethyl sulphide (*d*) methyl ethyl sulphide, (*e*) dimethyl sulphide

ing free bromine as the indicator with 0.05 *N* bromate-bromide as the titrating agent for small amounts of organic sulphides and disulphides. Thus various indicators were investigated and the dye Brilliant Ponceau 5R (purchased from Hartman-Leddon Co., Philadelphia, Pa.) was found satisfactory as noted earlier by Smith and Bliss (*7*) and by Smith and May (*8*), in that the end point could be established more definitely and the accuracy of the procedure was thereby considerably

improved. The Siggia and Edsberg procedure has also been modified by conducting the titration in the presence of benzene which gives rise to a system of two phases. Reasonably good and speedy titrations can be made in this system if the phases are intermixed by shaking. Example results on known substances are given in Table V.

Table V. Analyses of Known Solutions of Dimethyl Sulphide and Disulphide

Experiment	Material added: Substance	Material added: Amount, mg.	Material recovered: Amount, mg.	Material recovered: Per cent
Without Distillation				
1A	$(CH_3)_2S$	10.70	10.40	97.2
1B	$(CH_3)_2S$	10.70	10.24	95.8
1C	$(CH_3)_2S$	10.70	10.09	94.2
2A	$(CH_3)_2S_2$	3.16	3.11	98.4
2B	$(CH_3)_2S_2$	3.16	3.05	96.6
2C	$(CH_3)_2S_2$	3.73	3.73	100.0
2D	$(CH_3)_2S_2$	3.73	3.68	98.6

Experiment	Material added: $(CH_3)_2S$, mg.	Material added: $(CH_3)_2S_2$, mg.	Material recovered: $(CH_3)_2S_2$ in residue[a], %	Material recovered: $(CH_3)_2S$ in distillate, %
With Distillation (Residue and Condensate Analyzed)				
3	1.88	1.00	58.5	91
4	1.88	1.00	60.9	90
5	1.72	2.50	58.9	97.0
6	1.72	2.50	60.4	98.9

[a] Calculated on basis that all material in residue is $(CH_3)_2S_2$.

Individual determination of both dimethyl sulphide and dimethyl disulphide when these occur together in the benzene phase cannot be carried out by the Siggia and Edsberg method alone since only a total would be obtained. Thus an easy method for separation of the two substances was sought and was found based on their relative volatility in benzene solution. The differences that have been determined to exist in behavior of some substances of interest are illustrated in Fig. 4. These curves show, for example, that after batch distillation of 67% of the original benzene from a solution containing dimethyl sulphide and disulphide in low concentration, there will be found in the benzene distillate substantially all (98%) of the dimethyl sulphide present but only 40% of the dimethyl disulphide present in the system. For a mixture containing dimethyl sulphide and disulphide in unknown proportions, it has thus been possible to establish the analysis from knowledge of the relative volatility data given in Fig. 4 and of the results of Siggia and Edsberg type titrations carried out upon both the distillate and residue from Raleigh distillation of the benzene solution.

Results obtained with known substances are shown in Table V and it is seen that quite good analyses are obtained even with samples of only a milligram or two. The presence of diethyl sulphide or disulphide, or other benzene-soluble substances which react with bromine, would of course interfere with the determination of dimethyl sulphide and disulphide. However, the mass spectrometer data given above indicate that the dimethyl sulphide and disulphide are the sulphur-containing substances which are ordinarily to be expected.

As trials for the suggested methods, they have been used to determine the amounts of hydrogen sulphide, methyl mercaptan, dimethyl sulphide, and dimethyl disulphide in two gas and two liquid process streams flowing in a kraft pulp mill operating under apparently normal conditions and results are given in Table II. The major sulphur-containing component of a stack gas was found to be hydrogen sulphide; methyl mercaptan was of secondary importance and the amounts present of dimethyl sulphide and disulphide were nearly negligible. In a digester relief gas all four sulphur-containing substances were present in substantial proportions although with hydrogen sulphide at only about one-fiftieth the volume concentration of the other components. Analyses on digester blow gas condensate and on evaporator condensate samples showed all expected compounds present except that anomalous results were obtained for dimethyl sulphide in the evaporator condensate suggesting the presence of a nonvolatile unsaturated substance.

The applicability of the presently described methods to kraft black liquor has been considered in only a preliminary way. The potentiometric titration for methyl mercaptan has been attempted after lignin removal by acidification but satisfactory results have not as yet been obtained. Benzene extraction of dimethyl sulphide and disulphide from the liquor appears feasible after dilution to about 5% solids, but other substances which react with bromine are present in the benzene extract so that the distillation and bromate-bromide titration procedures do not yield consistent results for the organic sulphides. Thus for application of the present analysis scheme to black liquor, it seems necessary to develop ways to accomplish quantitative separation of volatile sulphur-containing compounds so that the analyses can be carried out without interference from nonvolatile solid components of black liquor. This has not been done in the present investigation because it was believed that the submitted procedures will be sufficient for most needs.

LITERATURE CITED

1. "American Petroleum Institute Research Project 44," Carnegie Institute of Technology. Catalog of Mass Spectral Data.

Serial No.	Substance	Name of Laboratory
157	CO_2	California Research Corp.
454	H_2S	California Research Corp.
778	CH_3SH	Union Oil Co. of California
79	C_2H_5SH	Union Oil Co. of California
92	CS_2	Union Oil Co. of California
174	COS	California Research Corp.
72	$CH{\equiv}CH$	Union Oil Co. of California
84	HCHO	Union Oil Co. of California
293	CH_3CHO	Humble Oil and Refining Co.
300	HCOOH	Humble Oil and Refining Co.
301	CH_3COOH	Humble Oil and Refining Co.

2. Tamele, M. W., Ryland, L. B., and Irvine, V. C., *Ind. Eng. Chem., Anal. Ed.* 13: 618–622 (1941).
3. Lykken, L., and Tuemmler, F. D., *Ind. Eng. Chem., Anal. Ed.* 14: 67 (1942).
4. Siggia, S., and Edsberg, R. L., *Anal. Chem.* 20: 938 (1948).
5. Klason, P., *Wochbl. Papierfabrik.* 39: 3859–3963 (1908); *C.A.* 3: 1082 (1909).
6. Bergstrom, H., and Trobeck, K. G., *Svensk Papperstidn.* 48: 49 (1945).
7. Smith, G. F., and Bliss, H. H., *J. Am. Chem. Soc.* 53: 2091 (1931).
8. Smith, G. F., and May, R. L., *Ind. Eng. Chem., Anal. Ed.* 13: 460 (1941).

Received Aug. 28, 1952. Presented at the Tri Association Meeting of the Pacific Section of TAPPI in Victoria, B. C., Sept. 26–27, 1952.

Acknowledgment is made to Allen M. Cadigan, Chief Chemist of the St. Regis Paper Co., Tacoma, Wash., for advice and assistance, and to Alden L. Crittenden and Murray E. Taylor of the Department of Chemistry and Chemical Engineering, University of Washington, Seattle, Wash., for assistance in mass spectrometer investigations.

ASSOCIATION NEWS AND EVENTS

Fibrous Agricultural Residues Conference

The Tenth Fibrous Agricultural Residues Conference will be held at the Quint Hotel, Belleville, Ont., Oct. 8–9, 1953.

Corrugated Container Conference

The Corrugated Container Conference will be held at the Statler Hotel, New York, N. Y., on Oct. 15–16, 1953.

The theme of the meeting will be "The Printing of Corrugated Containers."

Following is the revised program:

Thursday, October 15

8:30 a.m. Registration (Ball Room Foyer)

9:00 a.m. General Session (Grand Ball Room)

1. "Future Printer—Slotter Design and Developments," by E. B. Seegar, Samuel M. Langston Co., Camden, N. J.
2. "Printing Inks for Corrugated Containers," by Wm. E. Montoux, Sinclair & Valentine Co., New York, N. Y.
3. "The Relationship of Printing on Corrugated Boxes to Advertising and Sales, Package Engineering, and Production," by Paul Fitzsimmons, Jas. J. Matthews & Co., New York, N. Y.

12:30 p.m. Luncheon (where you will)

2:00 p.m. General Session (Grand Ball Room)

4. "Press Scheduling, Make-Ready, and Adjustments," by Stanley Baughman, Container Corp. of America, Manayunk, Pa.
5. "Press Operation—Maintenance and Control," by Howard Rosen, National Container Corp., New York, N. Y.
6. "The Effect of Printing Upon the Functional Properties of Corrugated Fiberboard Boxes," by A. W. Hoffman, Container Laboratories, Inc., New York, N. Y.
7. "Shall We Accept It?" by Paul Smith, Scott Paper Co., Chester, Pa.

6:00–7:00 p.m. Social Hour

7:30 p.m. Dinner

Speaker—William Sims

Friday, October 16

9:00 a.m. Plant Visits

To be announced

Eighth Engineering Conference

The Eighth TAPPI Engineering Conference will be held at the Sheraton-Mount Royal Hotel, Montreal, Que., on Oct. 26–29, 1953. Charles J. Sibler of the West Virginia Pulp & Paper Co., New York, is general chairman of the TAPPI Engineering Div., sponsor of the conference.

Monday, October 26

8:30 a.m. Registration (Ball Room Foyer)

9:15 a.m. General Session (Champlain Room)
C. J. Sibler, *Chairman*

Address of Welcome

9:30 a.m. Hydraulics Session (Champlain Room)
K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., *Chairman*

"Progress Report on Pipe Friction Studies," by R. E. Durst, University of Maine, Orono, Me.

10:45 a.m. Engineering Research and Machine Design Session (Champlain Room)
J. D. Lyall, Armstrong Cork Co., Lancaster, Pa., *Chairman*

"Constant Tension Devices," by George C. Ehemann, Jr., The Ohio Boxboard Co., Rittman, Ohio, and R. C. Berger, General Electric Co., Cleveland, Ohio.

"The Application Aspects of Paper Machine Differential Drives," by Sterling Skinner, Beloit Iron Works, Beloit, Wis.

"The Mechanics of Stress and Strain Occurring in a Fourdrinier Wire," by John D. Lyall, Armstrong Cork Co., Lancaster, Pa.

12:30 p.m. Engineering Division Luncheons

Drying and Ventilating Committee (Salon C)
Materials Handling Committee (Salon F)
Mill Maintenance and Materials Committee (Salon A)
Chemical Engineering Committee (Salon B)

2:00 p.m. Electrical Engineering Session (Champlain Room)
R. W. Foster, Champion Paper & Fibre Co., Canton, N. C. *Chairman*

"Grounded vs. Ungrounded Power Systems—A Demonstration. Review of Operating Experiences," by George P. Hobbs, Bowaters Newfoundland Pulp & Paper Mills Ltd., Corner Brook, Nfld., and R. H. Kaufmann, General Electric Co., Schenectady, N. Y.

"An Engineering Analysis of Downtime of Electric Section Drives," by R. F. Sorenson, Union Bag & Paper Corp., Savannah, Ga.

3:45 p.m. Discussion Meetings

Hydraulics (Salon I)

Discussion of TAPPI Research Project at the University of Maine on Pipe Friction Studies.

Engineering Research and Machine Design (Brittany Room)

Discussion of papers presented.

Electrical Engineering (Champlain Room)

"Selection of Chipper Drives" (Preliminary Report), by M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn.

Discussion of Cable Report, by A. O. Mortenson, St. Regis Paper Co., Pensacola, Fla.

Dinner (where you will)

Tuesday, October 27

9:00 a.m. Drying and Ventilating Session (Champlain Room)
Curt A. Young, Riegel Paper Corp., Milford, N. J., *Chairman*

"Variation of Drying Rates of Individual Driers Through the Drier Section," by A. E. Montgomery, J. O. Ross Engineering Corp., Chicago, Ill. (TAPPI Research Project No. 21.)

"The Mason-Neilan Moisture Drying Control System for Paper Machines," by J. M. McAlear, Mason-Neilan Regulator Co., Boston, Mass.

10:30 a.m. Materials Handling Session (Champlain Room)

A. P. Schnyder, Ebasco Services, Inc., New York, N. Y., *Chairman*

"Economics of Various Methods of Handling Mill Supply Chemicals," by H. A. Stoess, Jr., Fuller Co., Catasauqua, Pa.

"A Pulpwood Flume System," by John R. Fielding, Union Bag & Paper Corp., Savannah, Ga.

12:30 p.m. Engineering Division Luncheons

Hydraulics Committee (Salon E)
Engineering Research and Machine Design Committee (Salon B)
Electrical Engineering Committee (Salon A)
Mill Design and Economic Aspects Committee (Salon F)
Steam and Power Committee (Salon C)

2:00 p.m. Mill Maintenance and Materials Session (Champlain Room)

H. F. Parker, New York & Pennsylvania Co., Lock Haven, Pa., *Chairman*

"The Maintenance of Bleach Plant Equipment," by Harold H. Huseby, Northwest Paper Co., Cloquet, Minn.

"The Application of Noncorrosive Materials," by George Lydick, Beckett Paper Co., Hamilton, Ohio.

3:30 p.m. Discussion Meetings

Drying and Ventilating (Brittany Room)

Panel discussion of "Drying." Members of Panel: R. M. Cook, Midwest Fulton Machine Co., Dayton, Ohio; M. J. Barker, Beckett Paper Co., Hamilton, Ohio; W. J. O'Brien, O'Brien Steam Specialties Co., Syracuse, N. Y.; A. E. Montgomery, J. O. Ross Engineering Co., Chicago, Ill.; C. A. Young, Riegel Paper Corp., Milford, N. J.; J. C. Jordan, Chairman, C.P.P.A. Drying & Ventilating Committee; F. A. Garrett, Canadian International Paper Co.; J. M. McAlear, Mason-Neilan Reg. Co., Boston, Mass.

Materials Handling (Salon K)

Discussion of "Economics of Various Methods of Handling Mill Supply Chemicals."

Mill Maintenance and Materials (Salon I)

"Maintenance of Pipe Lines—Internal Cleaning," by Carl W. Ziegenbusch and M. V. Jones, Mead Corp., Chillicothe, Ohio.

6:00 p.m. Social Hour (Champlain Room)

7:30 p.m. Dinner (Ball Room)

B. K. Sandwell, Toronto, Ont., *Speaker*

Wednesday, October 28

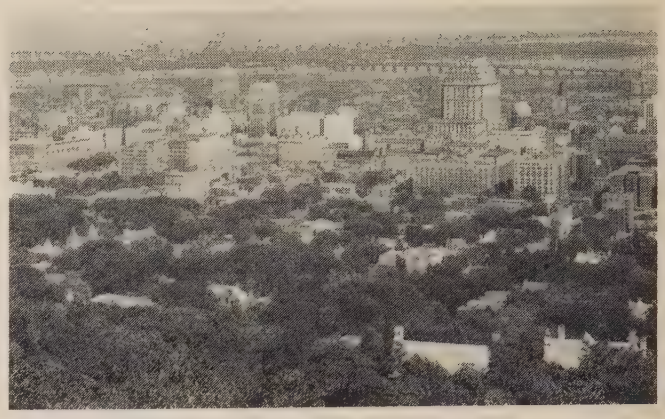
9:00 a.m. Digester Corrosion Session (Chemical Engineering) (Champlain Room)

J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga., *Chairman*, Chemical Engineering Committee, and Nicholas Shoumatoff, West Virginia Pulp & Paper Co., *Chairman*, Digester Corrosion Subcommittee, *Co-Chairmen*

"Comparative Analysis of Digester Corrosion Measurements," by T. E. Caywood, Armour Research Foundation, Chicago, Ill.

"Promising Indications of Causes of Corrosion in Alkaline Pulping Equipment," by Claud B. Christiansen, Pulp and Paper Research Institute of Canada, Montreal, P. Q.

"Safety Evaluation and Protection of Digesters," by W. B. Parker, Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn., and H. M. Canavan, Mutual Boiler and Machinery Insurance Co., Boston, Mass.



View of Montreal, site of the 8th Engineering Conference

11:00 a.m. Mill Design and Economic Aspects Session (Champlain Room)

R. A. Packard, Mutual Security Agency, Washington, D. C., *Chairman*

"Fire Protection in Pulp and Paper Mills," by R. C. Max, Factory Insurance Association, Milwaukee, Wis.

"Industrial Plant Construction in Canada," by F. M. Kraus, Stadler, Hurter & Co., Montreal, P. Q.

12:30 p.m. Engineering Division Luncheon (Ball Room)

Charles J. Sibler, *Toastmaster*

"The Urgent Needs of the Industry," by Douglas W. Ambridge, Abitibi Power & Paper Co., Ltd., Toronto, Ont.

2:30 p.m. Steam and Power Session (Champlain Room)

W. M. Wyburn, Federal Paper Board Co., Inc., Bogota, N. J. *Chairman*

"The ASME Boiler Code and Its Application in the United States and Canada," by E. C. Korten, Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.

"Case History of an 850 P.s.i.g. Topping Turbine Installation," by H. R. Emery, St. Regis Paper Co., Deferiet, N. Y., and P. H. Nelson, Chas. T. Main, Inc., Boston, Mass.

3:45 p.m. Discussion Meetings

Digester Corrosion (Brittany Room)

Discussion of session papers.

Mill Design and Economic Aspects (Salon I)

Discussion of papers presented.

Steam and Power (Champlain Room)

"Interpreting Performance Curves of Single and Double-Extraction Turbines and the Use of Heat Rates as a Method of Calculating Power Costs," by J. Gottlieb, Westinghouse Electric Corp., New York, N. Y.

7:00 p.m. Dinner Meeting for Committee Chairmen and Secretaries

Review of the 8th Engineering Conference
Discussion of the 1954 Conference
Review of Engineering Division Projects
TAPPI Engineering Data Sheets

Thursday, October 29

9:00 a.m. Inspection Tour of Dominion Bridge and Dominion Engineering Co. Plant, Montreal, P. Q.

Arrangements will be made to visit other industrial plants of particular interest to individuals.

Seventh Alkaline Pulping Conference

The Seventh Alkaline Pulping Conference will be held at the Rice Hotel, Houston, Tex., on Nov. 19–20, 1953. Fred W. Bishop of the Southland Paper Mills, Lufkin, Tex., is

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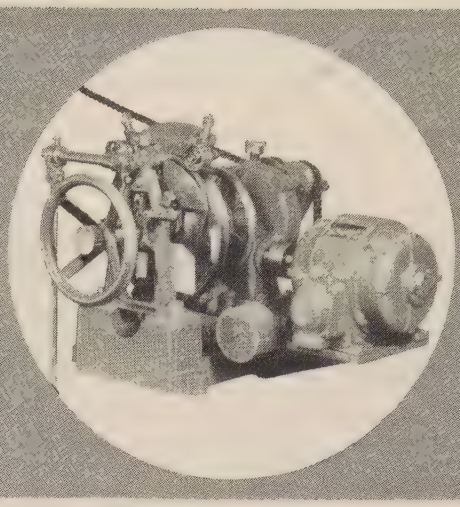

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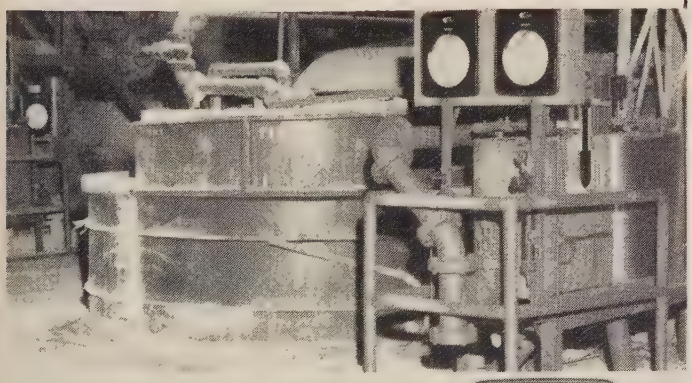

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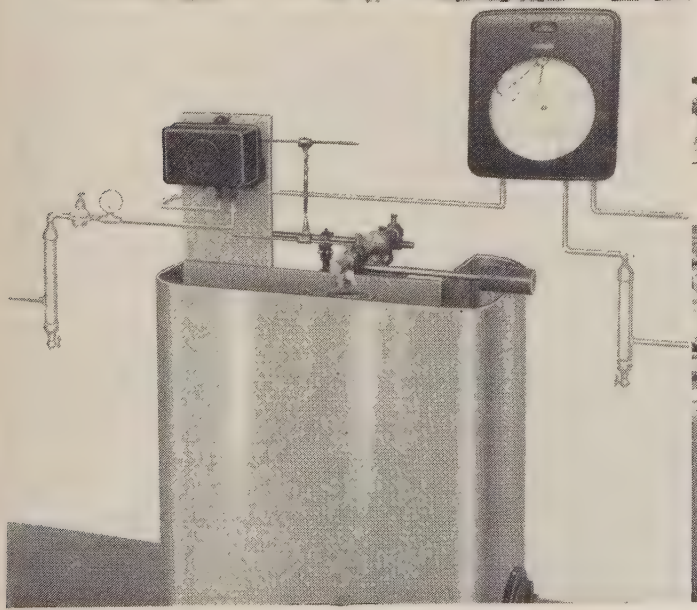

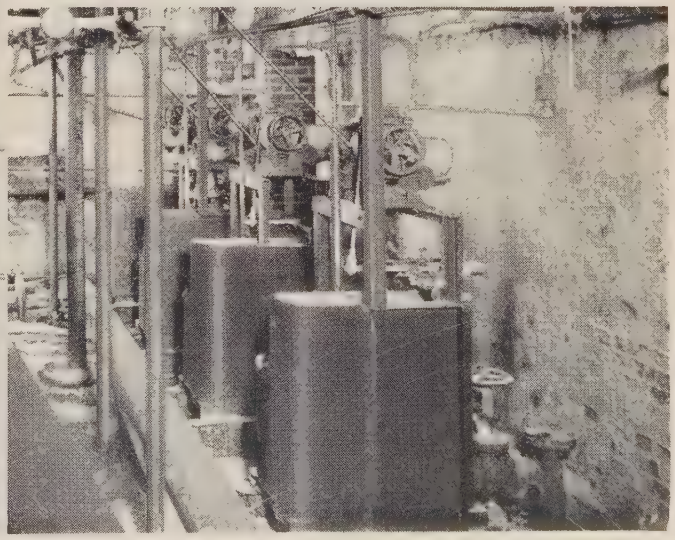

chairman of the TAPPI Alkaline Pulping Committee, sponsor of the conference. Ken Running of the Halifax Paper Co., Roanoke Rapids, N. C., is chairman of the Program Committee.

Following is the revised program.

Tuesday, November 17

4:00–8:00 p.m. Registration (Mezzanine)

Wednesday, November 18

8:30 a.m. Registration

9:30 a.m. Pulp Washing (Crystal Ball Room)

Fred W. Bishop, Southland Paper Mills, Inc., Lufkin, Tex., *Moderator*

1. "Current Report on Pressure Washing," by Lionel M. Sutherland and William S. Mounts, Sutherland Refiner Corp., Trenton, N. J.
2. "Pulp Washing Water; Heating, Supply, and Operating Difficulties," by Maurice Klein and J. M. Ralston, Jr. Union Bag & Paper Corp., Savannah, Ga.
3. "The Valveless Washer," by J. K. Perkins, Improved Machinery, Inc., Nashua, N. H.
4. "Effect of Digester and Liquor Room Operation on Pulp Washing," by Wilber Orr, St. Regis Paper Co., Pensacola, Fla.

12:30 p.m. Luncheon (Crystal Ball Room)

Speaker: Karl R. Bendetsen, former Undersecretary of Army, presently General Consultant and Assistant Division Manager (Texas Div.), Champion Paper and Fibre Co., Pasadena, Tex.

2:00 p.m. Pulp Washing and Screening (Crystal Ball Room)

K. D. Running, Halifax Paper Co., Inc., Roanoke Rapids, N. C., *Moderator*

1. "The Efficiency of a Four-Stage Pulp Washer vs. a Three-Stage Washer in a Kraft Mill," by E. A. Harper, Pulp Mill Superintendent, and Fritz Paul, Hudson Pulp & Paper Corp., Palatka, Fla.
2. "Performance of Cowan Screens on Kraft Pulp," by E. H. Smith, Assistant Technical Director, and W. S. Gardner, Assistant Pulp Mill Superintendent, Crossett Paper Mills, Crossett, Ark.
3. "Flat Screen vs. Ahlfor Screens for Bleachable Pine and Hardwood Sulphate Pulp," by Roy Homans, Development Engineer, and Malcolm Pineo, Technical Director, Brunswick Pulp and Paper Co., Brunswick, Ga.
4. "The Use of Centri•Cleaners and Vortraps on Semichemical Pulp," by A. L. Wiley, Technical Director A. E. Stafford, Chemical Engineer, and Russell Adams, Chemical Engineer, Riegel Carolina Corp., Acme, N. C.

6:00 p.m. Reception (Crystal Ball Room)

Thursday, November 19

8:30 a.m. Registration (Mezzanine)

9:00 a.m. Pulp Screening (South American Room)

M. B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga., *Moderator*

1. "Selective Particle Separation by Controlled Fluid Forces on a Flat Screen," by H. F. Schenk, Magnus Metal Corp., Fitchburg, Mass.
2. "Use of High Intensity Screens in Sulphate Pulping for Coarse Papers," by F. Cooper Ratliff, Gaylord Container Corp., Bogalusa, La.
3. "Use of a Jackson-Church Press in Handling Pulp Mill Rejects," by R. E. Bringman, Chief Chemist, St. Joe Paper Co., Port St. Joe, Fla.
4. Two additional papers may be presented on "Pulp Washing and Screening."

12:30 p.m. Luncheon (where you will)

2:00 p.m. Semichemical Pulping (South American Room)

J. N. McGovern, Forest Products Laboratory, Madison, Wis., *Moderator*

1. "The Influence of Fiberizing Variables in Producing Semichemical Pulp in a Commercial Disk Mill," by Friedrich A. Aflenzer, Forest Products Laboratory, Madison, Wis.
2. "Continuous High-Yield Kraft Pulping of Douglas-Fir Lumber Waste," by D. J. MacLaurin and J. F. Whalen, Institute of Paper Chemistry, Appleton, Wis.
3. Panel discussion of "Semichemical Pulping."

Friday, November 20

A tour of the Pasadena mill of Champion Paper & Fibre Co. has been scheduled for the morning period with the group being returned to the hotel before lunch. This trip will be available to those desiring to make a Friday departure. Another mill visit is scheduled for Friday to Southland Paper Mills, Inc., at Lufkin, Tex., which is 120 miles north of Houston. Luncheon will be provided for the visitors to Southland. All trips will be made on chartered buses.

On Saturday the University of Houston plays Texas Tech. in Rice Stadium. With a seating capacity of 75,000, tickets probably will be available to the individual at the gate. These two schools are top contenders for admission into the Southwestern Conference and this should be a very hotly contested football game.

A very fine ladies program is being formulated for the period of $2^1/_2$ or 3 days. The program will include a boat trip down the Ship Channel in the Port Commission's well-equipped *Sam Houston*. This is a trip designed to show the fabulous industrial installations of the immediate area. If not in conjunction with the boat trip, a visit will be scheduled otherwise to the San Jacinto Battleground with luncheon at the famous inn and sightseeing from the monument and on the battleship *Texas*. Houston has any number of fine shops and very new, nationally famous department stores. Fashion shows are in progress daily during luncheon at the Sky Terrace of Sakowitz and The Azalea Room of Foley's. Arrangements are in progress to schedule a visit to the Thursday luncheon show of the Smart Shop at the Emerald Room of The Shamrock Hotel.

Research Appropriations Committee

The Research Appropriations Committee of the Technical Association of the Pulp and Paper Industry presents the following progress report covering its activities for the first six months of 1953.

The primary purpose of the TAPPI research grants is to assist the committees of the Association in their projects through the appropriation of funds to be used to investigate technical problems relating to their projects.

Although the responsibility of administering the funds of the Association for research projects is vested in the Executive Committees, this responsibility is delegated to a Research Appropriations Committee comprised of 12 members of the Association, including the president and vice-president, *ex-officio*.

Unanimous approval of a research request must be given by the Research Appropriations Committee. In the event that one or more members of a committee object to the approval of a research project the request is referred to the Executive Committee for final consideration.

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The present personnel of the Research Appropriations Committee is as follows:

John L. Parsons, Chairman, Waterville, Me.
Allen Abrams (1953), Marathon Corp., Rothschild, Wis.
A. E. Bachmann (1953), Missisquoi Corp., Sheldon Springs, Vt.
H. W. Bialkowsky (1953), Pulp Div., Weyerhaeuser Timber Co., Longview, Wash.
W. F. Gillespie (1954), Gaylord Container Corp., Bogalusa, La.
J. W. Hemphill (1954), Johns-Manville Corp., New York, N. Y.
J. D. Malcolmson (1954), San Francisco, Calif.
A. L. Sherwood (1955), Sutherland Paper Co., Kalamazoo, Mich.
W. H. Swanson (1955), Kimberly-Clark Corp.
K. P. Goehegan (1955), Howard Paper Mills, Dayton, Ohio.
G. H. Pringle (*ex-officio*), Mead Corp., Chillicothe, Ohio.
K. O. Elderkin (*ex-officio*), Bowaters Southern Paper Corp., Calhoun, Tenn.

Request No.	*Project*	*Committee*	*Amount*
50	Study of Corrosion in Alkaline Digesters by Analysis of Wall Thickness Measurements	Chemical Engineering (Digester Corrosion Subcommittee)	$6000
51	Permeability of Plastic Treated Paper to Gases and Liquids	Plastics	5000–7000
52*	Study of Skinlike Substance from Residues of Pulp Fiber Treatment (Continuation of No. 30)	Fundamental Research	2500
53	Dye Adsorption Method of Determining the External Specific Surface of Pulp and Correlation with Other Fiber Properties (Continuation of No. 31)	Fundamental Research	2800
54	Structure of Lignin (Continuation of No. 24)	Fundamental Research	1500
55	Sulphonation of Lignin	Fundamental Research	3000
56	A Study of Certain Factors Involved in Semichemical Pulping	Fundamental Research	5000
57	Method for the Determination of the Chain Length of Cellulose (Continuation of No. 48)	Chemical Methods	900
58	Development of a Method for the Measurement of the Ratio of Crystalline to Amorphous Material in Cellulose	Chemical Methods	900
59*	Dirt in Wood Chips. Revision of Tentative Standard T 14 m-47	Fibrous Materials	2050
60**	A Study of the Reaction Between Water and Cellulose in the Temperature Range 100 and 225 °C.	Fundamental Research	2000
61**	Losses of Straw Stored in Ricks	Fibrous Agricultural Residues	5500

Requests identified by one asterisk (Nos. 52 and 59) were not unanimously approved but received a majority approval by the committee and will be referred to the Executive Committee for final decision.

Nos. 60 and 61, marked with a double asterisk, are now being considered by the committee.

Up to July 1, 1953, research grants for the current year amounting to $27,100 have been approved by the committee. This is more than double the amount for the same period in 1952. Two requests totaling $4550 are being referred to the Executive Committee. Amounts totaling $7500 are awaiting our committee approval.

John L. Parsons, *Chairman*
Research Appropriations Committee

Southeastern

The 1953–54 schedule of meetings of the Southeastern Section as announced by Charles M. Rogers, vice-chairman, is as follows:

Sept. 25, 1953—Frederica Yacht Club, Brunswick, Ga.
Dec. 4, 1953—Fort Sumter Hotel, Charleston, S. C.
Jan. 22, 1954—Hotel Dempsey, Macon, Ga.
March 19, 1954—George Washington Hotel, Jacksonville, Fla.
May 14, 1954—Hotel De Soto, Savannah, Ga.

Delaware Valley

The 1953–54 schedule of meetings of the Delaware Valley Section is as follows:

Sept. 25, 1953—Hercules Powder Co. Experiment Station, Wilmington, Del., Dinner at the Hercules Country Club. A presentation "Tools for Research" will be made by the Hercules Experiment Station staff.
Oct. 22, 1953—Engineers Club, Philadelphia, Pa. Subject, "Corrosion."
Dec. 4, 1953—Riegel Ridge, N. J., clubhouse of the Riegel Paper Corp. Panel discussion on "Dimensional Stability of Paper."
Jan. 28, 1954—Engineers Club, Philadelphia, Pa. Subject, "Semichemical Pulping."
March 25, 1954—Engineers Club, Philadelphia, Pa. Panel discussion on "Odor and Food Packaging."
April 27, 1954—Engineers Club, Philadelphia, Pa. Program on "Mill Instrumentation."
May 27, 1954—Engineers Club, Philadelphia, Pa. Edward J. Albert Competition Award Program.

Pacific

The 1953 schedule of meetings of the Pacific Section is as follows:

Sept. 25, 1953—Tacoma, Wash. Annual engineering meeting.
Nov. 31, 1953—Longview, Wash. Subject, "Products from Wood."
Jan. 19, 1954—Everett, Wash. Subject, "General Mill Problems."
March 19, 1954—West Linn, Ore. Annual Shibley Award Contest.
May 20–22, 1954—Gearhart, Ore. Joint meeting with the Pacific Div. of the Superintendents Association.

All technical meetings start at 2:00 p.m. and will be followed by dinner.

The annual seminar sponsored by the Section will be held at Seattle, Wash., on Sept. 23–24, 1953, and at Portland, Ore., on Sept. 28–29, 1953.

Ohio

The 1953–54 schedule of meetings of the Ohio Section will be as follows:

Oct. 8, 1953 (American Legion Hall, Middletown, Ohio): Panel discussion on "Recent Pulp Developments."
Nov. 10, 1953 (American Legion Hall): Panel discussion of "Problems of Closing a White Water System." Joint meeting with the Miami Valley Div. of the Superintendents Association.
Dec. 8, 1953 (American Legion Hall): "Radio Isotopes in the Paper Industry," by C. A. Sankey, Forest Products Lab, Madison, Wis.
Jan. 12, 1954 (American Legion Hall): "Statistical Quality Control," by B. E. Sooy, Gardner Board & Carton Co., Middletown, Ohio.
Feb. 11, 1954 (Manchester Hotel, Middletown, Ohio): "Printing—Past, Present, and Future," by W. C. Huebner, Huebner Labs., Mamaroneck, N. Y.
March 9, 1954 (Manchester Hotel): Address by Sidney D. Kirkpatrick, McGraw-Hill Publishing Co., New York, N. Y.
April 11, 1954 (Hartwell Country Club, Cincinnati, Ohio): Annual meeting.

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for common complaints at the wet end of Fourdriniers

"K" Monel creping doctor on one of the world's largest paper towelling machines. "K" Monel was recommended by the makers of the blade, Lodding Engineering Corp., Worcester, Mass., because of its excellent resistance to corrosion, abrasion and wear.

Do your paper machines suffer from a tired, run-down feeling around the doctor blades?

Fortunately, there's a simple cure for this disease. It means surgery — but the operation is safe and painless. Just remove the old blades and replace with blades of "K"® Monel. It's enough to make any patient feel like a new machine.

And why shouldn't it? Now wear and corrosion, the worst enemies of doctor blade life and performance, are under control.

Bring on your corrosive paper stocks, sours, cleaners and chemicals! Let them try to make headway against these new blades. They find that "K" Monel is stronger and harder than structural steel. That it is highly resistant to corrosion. And that it is non-rusting, too.

"K" Monel doctor blade surfaces stay smooth, and wear uniformly. The blades need less honing, and less regrinding. They avoid pick-up of metallic beads and rust particles that might damage an adjacent roll or contaminate a whole run of paper.

Keep "K" Monel in mind wherever corrosion-resisting, long-wearing doctor blades are required. And remember its companion Inco Nickel Alloy, Monel®, for calender rolls, roll covers, scrapers, save-alls and winding wire.

It is advisable to place equipment orders, as approved by N.P.A., with your supplier well in advance of scheduled use. Distributors of Inco Nickel Alloys can supply the latest information on availability from warehouse and mill. And we'll be glad, of course, to tell you more about how "K" Monel blades can "doctor" a specific problem on one of your paper machines. Just write us.

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NIMONIC® ALLOYS • NICKEL • LOW CARBON NICKEL • DURANICKEL®

Empire State (Northern District)

The Northern District of the Empire State Section will hold its meetings in 1953–54 at La Martina's Restaurant in Watertown, N. Y., on the second Thursday of each month. Following is the schedule:

Oct. 8, 1953: "Present Developments in European Pulp and Paper Manufacture," by K. A. Arnold, St. Regis Paper Co., Deferiet, N. Y.
Nov. 12, 1953: "Paper," by Henry J. Perry, Waste Paper Utilization Council, New York, N. Y.
Dec. 10, 1953: "Slime Control," by Paul A. Sartoretto, W. A. Cleary Corp., New Brunswick, N. J.
Jan. 14, 1954: "Paper," by Wilfred Galley, E. B. Eddy Co., Hull, P. Q.
Feb. 11, 1954: To be announced.
March 11, 1954: To be announced.
April 3, 1954: To be announced.
May 13, 1954: Annual meeting and Ladies Night.

Empire State (Eastern District)

Allen A. Lowe, publicity chairman, has announced the following schedule of meetings of the Eastern District of the Empire State Section for 1953–54 to be held in Glens Falls, N. Y.

Oct. 15, 1953: "The Manufacture and Use of Fourdrinier Wires," by Smith McLandress, vice-president, Appleton Wire Works, Appleton, Wis.
Nov. 19, 1953: "Training Program."
Dec. 17, 1953: "Wood Conservation and Utilization."
Jan. 21, 1954: "Routine Control Methods."
Feb. 18, 1954: "Chemigroundwood Pulping."
March 18, 1954: "Centrifugal Cleaning Eauipment."
April 15, 1954: Junior paper presentation competition.
May 20, 1954: Annual meeting and Ladies Night.

Maine-New Hampshire

The Fall meeting of the Maine-New Hampshire Section will be held at the Lafayette Hotel, Portland, Me., on Oct. 23–24, 1953. There will be a symposium on "The Addition of Materials to the Paper Machine Furnish to Improve Strength and Quality."

Empire State (Metropolitan District)

The 1953–54 schedule of meetings of the Empire State Section (Metropolitan District) is as follows (all meetings are held at Fraunces Tavern in New York City. It was at this tavern that General Washington bade farewell to his officers. There is an interesting museum of the continental army on the floor above the dining rooms):

Sept. 22, 1953—Panel discussion on "Product Development in Industrial Packaging."
Oct. 20, 1953—"Wastepaper Problems."
Nov. 10, 1953; Dec. 8, 1953; Jan. 12, 1954; March 9, 1954; April 13, 1954; and May 11, 1954 (programs to be announced).

Data Sheets Committee

J. W. Hemphill, chairman of the TAPPI Data Sheets Committee in the Engineering Div., announces the personnel of the reorganized committee as follows:

W. M. Wyburn, Federal Paperboard Co., Bogota, N. J. (representing the Steam and Power Committee).
W. R. McNally, Link-Belt Co., Chicago, Ill. (representing the Materials Handling Committee).
Curt A. Young, Riegel Paper Corp., Milford, N. J. (representing the Drying and Ventilating Committee).
Dwight E. Jones, E. D. Jones & Sons, Pittsfield, Mass. (representing the Engineering Research and Machine Design Committee).
R. A. Packard, Mutual Security Administration, Washington, D. C. (representing the Mill Design and Economic Aspects Committee).
R. G. Quinn, Johns-Manville Corp., Manville, N. J. (representing the Hydraulics Committee).
H. F. Parker, New York & Pennsylvania Co., Lock Haven, Pa. (representing the Mill Maintenance and Materials Committee).
G. W. Knapp, General Electric Co., Schenectady, N. Y. (representing the Electrical Engineering Committee).
L. C. Jenness, University of Maine, Orono, Me. (representing the Chemical Engineering Committee).

J. W. Hemphill, *Chairman, Johns-Manville Sales Co., New York, N. Y.*

Starch Monograph

At the time of the Coating Conference in Cincinnati a meeting was held of the members of the Coating Committee who are helping to rewrite the Starch Monograph. Those in attendance at this meeting were: Jack Wilbur, Fred Denham, Chester G. Landes, T. A. White, W. F. Smart, H. C. Schwalbe, C. C. Kesler, L. J. Wood, E. P. Gillan, M. L. Cushing, John E. Ward, Frank Kaulakis, H. R. Wheeler, Jr., J. M. Newton, Lloyd Silvernail, and Norman F. Kennedy.

At this meeting the outline for the various chapters was discussed and some rearrangement of authors was made. The following represents the revised outline for authors for the Starch Monograph:

General Introduction, by F. Frost.
"Types and Functions of Coating Adhesives," by F. Frost.
"Chemistry of Starch in Relation to Its Use in Paper Coating," by R. W. Kerr and T. Schoch.
"Chemical and Physical Examination of Starches," by K. M. Gaver.
"Varieties of Starches," by Aubrey White and L. Gussman.
"Modified Starches for Paper Coating," by John Newton and H. R. Wheeler.
"Derivatives of Starch for Paper Coating," by C. C. Kesler and C. G. Caldwell.
"Preparation and Handling of Modified Starches," by F. Kaulakis and J. T. Loomer.
"Enzyme Conversion of Starch for Paper Coating," by H. C. Schwalbe and F. Denham.
"Viscosity of Starch Solutions," by Monroe Mason.
"Starch and Other Adhesive Combinations," by J. E. Sullivan and Lloyd Silvernail.
"Additives and Adjuncts Used in Starch Coatings," by D. D. Ritson and J. E. Ward.
"Coating Formulas," by J. Bullard.
"Methods of Application of Starch Coatings," by Fred Culp.
"Properties and Testing of Coating Colors and Coated Papers," by Jack Wilbur.
"Water Resistant Starch Coatings," by W. C. Black.
"Economics of Starch Production," by Norman Kennedy and L. Gussman.

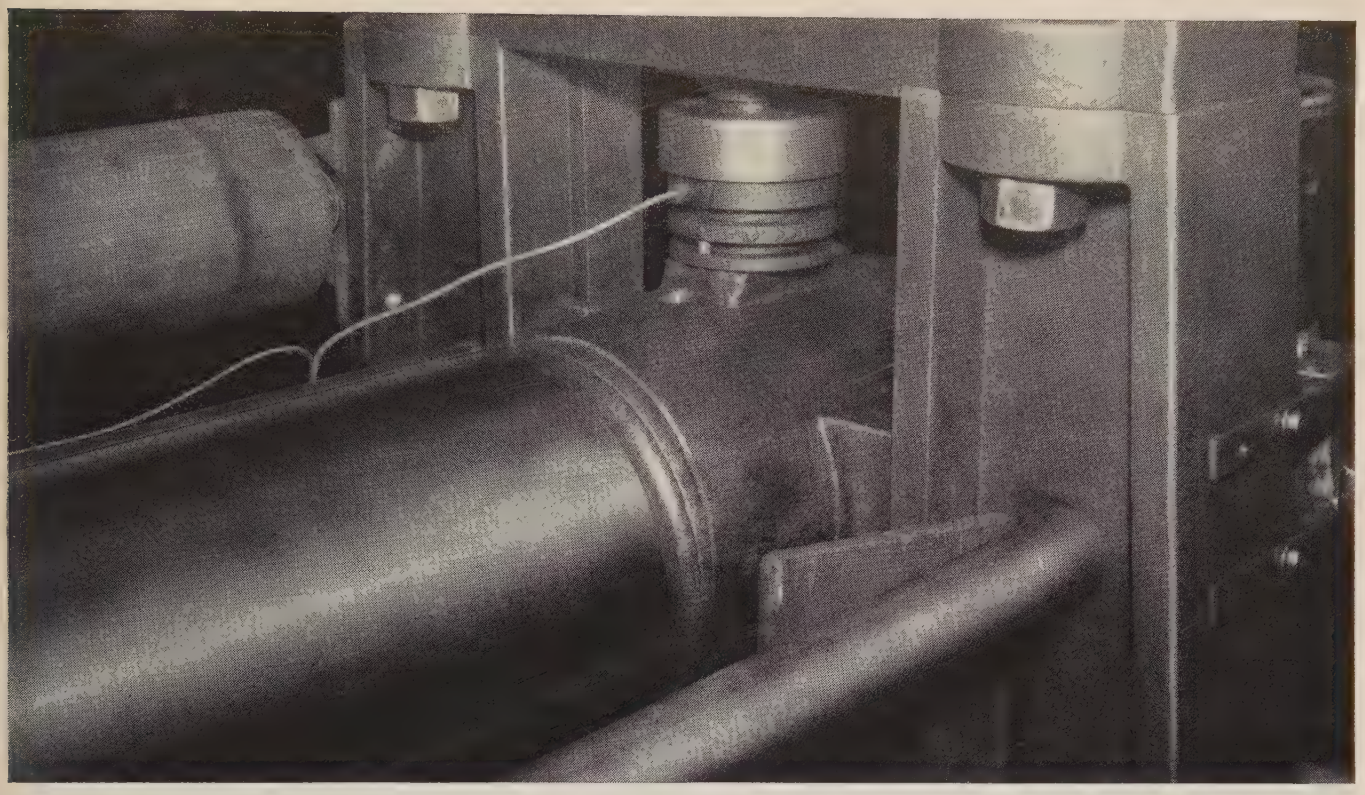
A number of suggestions in addition to those included in the First Progress Report were made at this meeting. November 1 was set as a deadline for submission of all chapters in the form of a first draft. Preferably 25 copies should be submitted at that time in order that these can be circulated among all the members for comments. This is important in that it will give each member an idea of the scope of the various chapters and make it possible at the time of the Annual Meeting in February to review and reorganize the various chapters.

The suggestion was made that where two authors have been assigned to one chapter, a single member be selected as the major author to be responsible for getting the work done on time. For example, in the chapter on Varieties of Starches, Aubrey White has agreed to act as the senior author and take the responsibility of seeing that the work progresses on schedule.

The suggestion was made and heartily approved by the group that as much as possible of Schoch's recent article, published shortly after the Coating Conference in Chicago be included in the new Monograph. It was suggested that Schoch be contacted regarding this in the near future.

In the enzyme chapter, the suggestion was made that

Knowlton Brothers don't guess supercalender roll pressure!



THEY don't have to adjust their supercalender roll by guess and by gosh at the Watertown, N. Y., plant of Knowlton Brothers, manufacturers of specialty papers. A Taylor Calender Roll Pressure Recorder enables the operator to easily apply any required nip pressure *uniformly across the roll*, thus insuring the exact finish required. With the roll pressure uniformly adjusted to the right value, power consumption is considerably reduced—and so is frictional wear, which means that the life of fabricated intermediate rolls is greatly prolonged.

This fine adjustment is made possible by Taylor's Volumetric Compression Load Elements, (*see photo above*) which are installed to measure the compressive force between the top lever and the top roll bearing each end of the roll. Consequently the *actual* load exerted on each top roll bearing by the weight and lever arrangement is measured.

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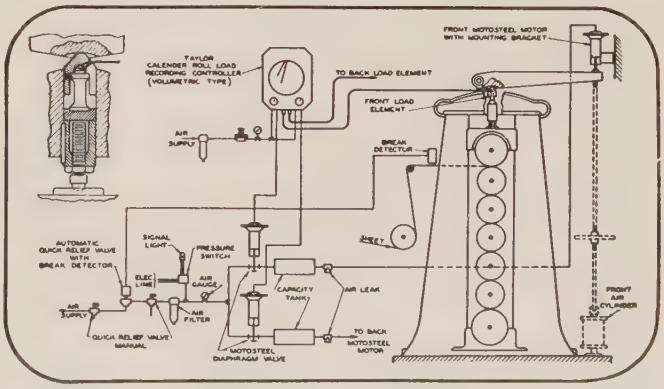
Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.



Another typical installation system, in this case for recording *and automatically controlling* supercalender roll pressure.

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

sections be devoted to the theory and history of enzyme conversions. Also, reference should be made to the economics of the process and the use and development of specially treated starches for this purpose. John Newton has agreed to collaborate with the authors of this chapter.

The section on modified starches for paper coating will include oxidized, dextrinized, and acid modified starches, but not specially treated starches for enzyme conversion, since these will be covered in the chapter on enzyme conversions.

In the chapter on Viscosity of Starch Solutions, it was agreed that all of the common viscometers should be covered including the CIRF, Dudley and Alexander pipets, Saybolt, Stormer, Macmichael, Brookfield, Brabender, and Scott.

The chapter on Starch and Other Adhesive Combinations should cover casein, polyvinyl alcohol, polyvinyl acetate, alginates, latices, and others.

A tentative outline for the chapter on Additives and Adjuncts Used in Starch Coatings was presented by Landes and was as follows:

I. *Fluidifiers and Plasticizers:* Sugars; Polyhydric alcohols; Amino and amido compounds; Fatty acid complexes.

II. *Wax Sizes:* Acid stable types; Alkaline stable types.

III. *Soaps—Leveling Agents:* Soaps; Metallic soap emulsions; Fatty acid esters and amines; Sulphonated oils.

IV. *Preservatives:* Formaldehyde; Phenol, xylols;

TAPPI-WMC Statistical Methods Conference

Front row, l. to r.: Frank S. Winship, Personal Products Corp., Milltown, N. J.; Guy R. Benson, The Upjohn Co., Kalamazoo; Robert Becker, Riegel Paper Corp., Milford, N. J.; William R. Saxton, Industrial Cellulose Research Ltd., Hawkesbury, Ont.; Arthur E. Reynolds, West Virginia Pulp & Paper Co., Williamsburg, Pa.; F. J. Kizale, International Business Machines Corp., Endicott, N. Y.; Harry C. Kinne, Oxford Paper Co., Rumford, Me.; Harold T. Hixon, Mead Corp., Chillicothe, Ohio, and Fred Armstrong, E. B. Eddy Co., Hull, Que.

Second row: Donald F. Jenkins, Champion Paper & Fibre Co., Hamilton, Ohio; George W. Hartley, International Business Machines Corp., Endicott, N. Y.; Paul L. Page, Imperial Paper & Color Corp., Glens Falls, N. Y.; Virgil W. Westdale, Burroughs Corp., Detroit, Mich.; Robert B. Ellis, Sealright Co., Fulton, N. Y.; John K. Dyer, Gaylord Container Corp., Bogalusa, La.; Lufra J. Trahan, International Paper Co., Mobile, Ala., and R. B. Tipton, International Paper Co., Bastrop, La.

Third row: J. G. Ferguson, International Paper Co., Georgetown, S. C.: W. L. Cassiday, Alton Box Board Co., Alton, Ill.; Edward Berkyto, Kenogami, Que.: Arthur Hupp, Watervliet Paper Co., Watervliet, Mich.; Donald R. Peterson, Cross Bay Lumber Co., Coos Bay, Ore.; Thurman E. Bercaw, Gaylord Container Corp., Bogalusa, La.; John D. Line, Mosinee Paper Mills Co., Mosinee, Wis., and Albert Austin, International Paper Co., Bastrop, La.

Fourth row: Charles Bicking, Army Ordnance Corps, Washington, D. C.; Martin G. Galbraith, Sutherland Paper Co., Kalamazoo; Eric W. Willcock, E. B. Eddy Co., Hull, Que.; Ralph H. Field, Keyes Fibre Co., Waterville, Me.; Henry G. Nelson, Owens-Illinois Glass Co., Toledo, Ohio; Rene Schneider, Ohio Box Board Co., Rittman, Ohio; Hubert O. Davis, Gaylord Container Corp., Bogalusa, La., and Jules W. Bell, International Paper Co., Mobile, Ala.

Fifth row: Arthur Thurn, Champion Paper & Fibre Co., Hamilton, Ohio; Paul W. Bartholomew, Minnesota and Ontario Paper Co., International Falls, Minn.; J. R. Arnold, Escanaba Paper Co., Escanaba, Mich.; Doyle F. Dykes, Macon Kraft Co., Macon, Ga.; Joseph Hajek, General Foods Corp., Battle Creek, Mich.; John C. Waddell, American Box Board Co., Grand Rapids, Mich., and Norval F. Wilson, Missisquoi Corp., Sheldon Springs, Vt.

Sixth row: J. R. Arthur, Port Huron Sulphite & Paper Co., Port Huron, Mich.; Geoffrey Beale, University of Connecticut, Storrs, Conn.;. Roderick Perkins, Marinette Paper Co., Marinette, Wis.; Charles H. Butler, Western Michigan College; William A. Leftwich, International Paper Co., Natchez, Miss.; Kenneth W. Warde, Fox River Paper Corp., Appleton, Wis.; Gaylord R. Thompson, Marathon Corp., Menasha, Wis., and Fred R. Beeler, Western Michigan College.

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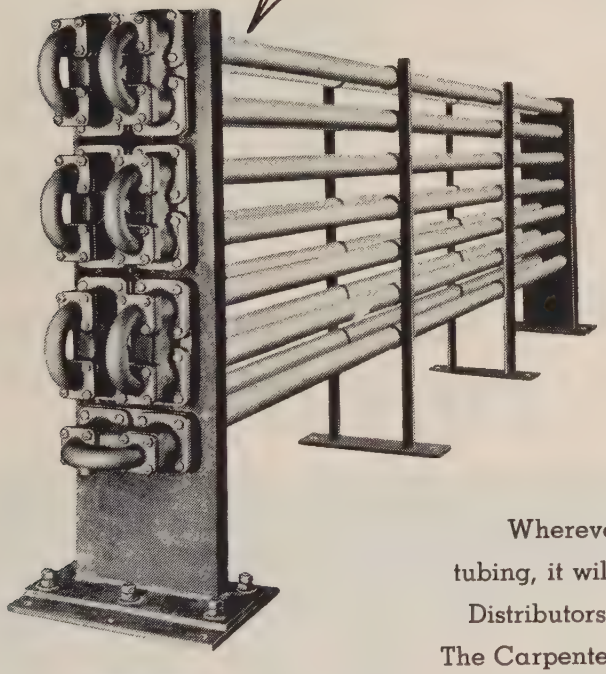

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J. P. Casey, *Chairman*
Subcommittee on Starch Monograph

Second Statistics Conference (1953)

The second annual "Conference on the Application of Statistical Methods in the Pulp and Paper Industry" co-sponsored by the Technical Association of the Pulp and Paper Industry and a university was held at Western Michigan College, Kalamazoo, Mich., on June 15–26, 1953. Fifty-one men representing 37 companies from 16 states and Canada attended. The broad interest shown in this activity is illustrated by the fact that this geographical distribution included men from as far East as Maine, as far West as Oregon, North from Canada, and South from Alabama.

The purpose of the conference was to acquaint paper mill personnel with the applicability of statistical methods to their problems. It was designed to give preliminary training to those individuals who attended so that they may use statistical methods in research, production, and quality control.

The program was conducted by four regular lecturers: Geoffrey Beall of the University of Connecticut, formerly of The Institute of Paper Chemistry; Charles A. Bicking, Research and Development Div., Ordnance Dept., formerly with Hercules Powder Co.; Fred Beeler and Charles H. Butler, Mathematics Dept., Western Michigan College.

Four evenings each week a guest speaker from industry told of his experiences in applying statistical methods to paper problems. This was one of the important features of the conference as it tied in the practical applications with the theory taught during the daytime classes. Those speaking at this conference were: Arthur Bender, Delco-Remy Div., General Motors Corp., Anderson, Ind.; O. H. Somers, Western Printing and Lithographing Co., Racine, Wis.; Arthur C. Dreshfield, consulting chemist and chemical engineer, LaGrange, Ill.; Robert H. Lace, The Lincoln Paper Co., Chicago, Ill.; Fred R. Sheldon, Buffalo Electro-Chemical Co., Buffalo, N. Y.; Richard T. Trelfa, Watervliet Paper Co., Watervliet, Mich.; Charles A. Bicking, Ordnance Dept., Washington, D. C.; B. E. Sooy, Gardiner Board and Carton Co., Middletown, Ohio.

Since the conference was held some of those attending have written expressing a high degree of satisfaction with the conference. Because of the success this year as well as the first conference held at the University of Maine, it is expected that a third one will be held further West or in the South next Summer.

The TAPPI Committee on Statistics wishes to express its thanks to the Marchant, Monroe, and Friden Cos. for providing, at no expense to the conference, 38 new automatic electric calculating machines, and one or more staff people as instructors to help the men become acquainted with the machines; to the Kalamazoo Valley Section of TAPPI for sponsoring two week-end events—a dinner at the Gull Lake Country Club and a series of trips to various mills; to the many members of the Western Michigan College staff who contributed so much to the success of the conference, and especially to Charles H. Butler and Fred Beeler who made all the arrangements for conducting the conference and acted as members of the instructing staff; to Geoffrey Beall and Charles A. Bicking for organizing the lectures and acting as members of the instructing staff; and to all of the guest speakers who helped immeasurably in making the conference a success.

John F. Langmaid, Jr., *Chairman*
TAPPI Committee on Statistics

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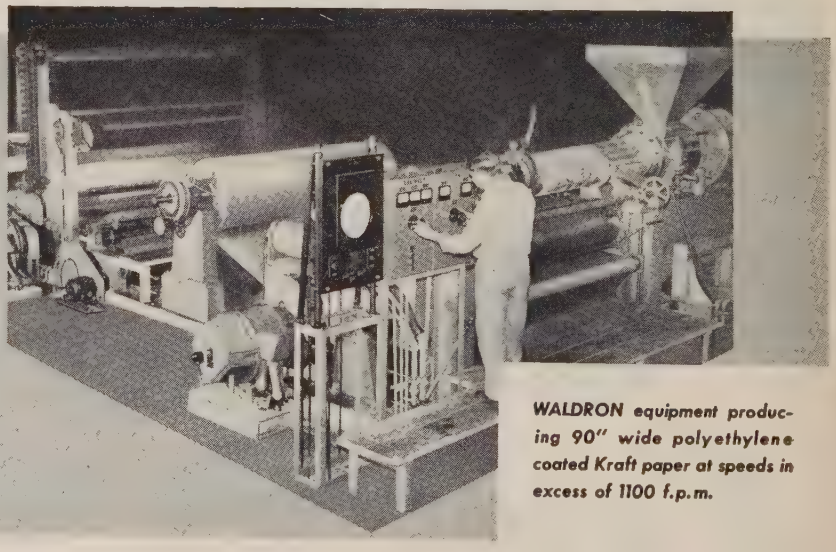

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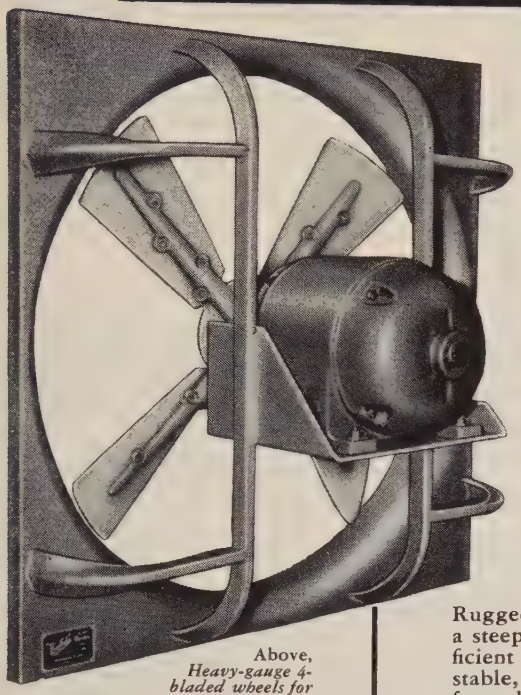

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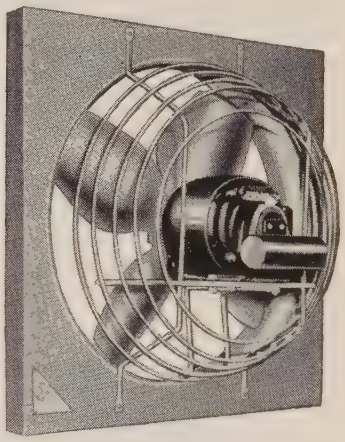

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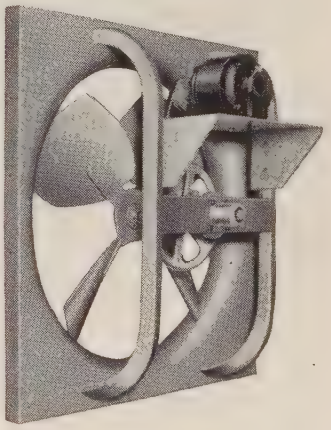

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Warren E. Abrams, Industrial Engineer, Kennebec Paper Corp., Augusta, Me., a 1950 graduate of the Virginia Polytechnic Institute.

William D. Arbuthnot, Plant Superintendent, Fibre Board Container Corp., Richmond, Va., a 1940 graduate of North Carolina State College.

Walter A. Banks, Chief Engineer, B-C International Ltd., London, England, a 1939 graduate of S. E. E. Technical College.

Charles H. Bechtel, Chief Chemist, Standard Paper Mfg. Co., Richmond, Va., a 1949 graduate of the University of South Carolina.

Eudore A. Berry, Sales Engineer, Oliver United Filters, Inc., Oakland, Calif., a 1940 graduate of the University of Washington.

Robert N. Brownlee, Director of Quality Control, Personal Products Corp., Milltown, N. J., a 1937 graduate of the University of Minnesota.

Harold R. Curson, Industrial Engineer, General Box Co., Des Plaines, Ill., a 1947 graduate of Purdue University.

Heinz Dankert, Color Chemist, Cassella Farbwerke Mainkur, Frankfurt (Main)-Fechenheim, Germany. Attended the Technical University, Darmstadt.

William H. Deakin, Manager, Brittains Ltd., Ivy House Paper Mills, Hanley, Stoke-on-Trent, England. Attended North Staffordshire Technical College.

Samuel L. Elam, Jr., Vice-President, Elam-Elkhart Stationery Co., Inc., Allegan, Mich. Attended St. Louis University.

Charles G. Eubank, Manager, Kimberly-Clark Corp., Memphis, Tenn., a 1923 graduate of the University of Minnesota, and a 1926 graduate of the University of Chicago.

Luis V. Fernandez, Superintendent, Cia de las Fabricas de papel de San Rafael y Anexas, San Rafael, Edo de Mexico, a 1952 graduate of Universidad Nacional Autonoma de Mexico.

Peter J. Fitzpatrick, Sales Trainee, American Cyanamid Co., New York, N. Y., a 1940 graduate of Louisiana State University, and a 1953 graduate of Columbia University.

Robin G. Graham, Company Director, Foy's Woodpulp Ltd., London, England. Attended Nautical College, Pangbourne, Berkshire.

Downey M. Gray, Jr., Corrugated Production Manager, General Box Co., Louisville, Ky., a 1941 graduate of Dartmouth College.

Walter R. Kitson, Jr., Paper Mill Engineer, Oswego Falls-Sealright Corp., Fulton, N. Y., a 1940 graduate of Michigan College of Mining and Technology.

Howard J. LaBerge, Chemical Engineer, St. Lawrence Corp., East Angus, P. Q., Canada, a 1952 graduate of the University of Toronto.

Ferdinand K. Levy, Assistant to Vice-President in Charge of Production, Lengsfield Bros., Inc., New Orleans, La., a 1950 graduate of Tulane University.

Gilbert L. Lewis, General Manager, Protexall Permanent Process Service, Kansas City, Mo.

David G. McRitchie, Sales Engineer, Stowe-Woodward, Inc. Newton Upper Falls, Mass., a 1941 graduate of the College of Charleston.

Otto Merlau, Chemist and Secretary, Union of Pulp, Paper and Board Industry of Hessen, Union of Packing Paper Industry of Germany, Darmstadt, Germany. A graduate of the Technical College.

Richard C. Myles, Manager of Sales Service and Complaint Div., St. Regis Paper Co., New York, N. Y. Attended New York University.

Eric B. Norman, Sales Engineer, B. F. Perkins & Son, Inc., Holyoke, Mass. Attended Carleton College.

Holger Nystrom, Director of Research, Aktiebolaget Statens Skogsindustrier, Djursholm, Sweden, a graduate of the University of Stockholm.

Albert L. Safine, Chief Chemist, Fibreboard Products, Inc., Stockton, Calif., a 1931 graduate of the University of California.

Raymond B. Stein, Jr., Divisional Manager, The Drackett Products Co., Chicago, Ill., a 1947 graduate of Pennsylvania State College.

Harold L. Taylor, Sales, Pennsylvania Industrial Chemical Corp., Chester, Pa., a 1923 graduate of Princeton University.

George E. Wozasek, Engineer, Dr. Franz Feurstein K.G., Traun/Line, Austria, a 1950 graduate of Columbia University.

TAPPI Notes

Warren A. Abrams, Industrial Engineer for the Hudson Pulp and Paper Co., has been transferred from New York, N. Y., to the Kennebec Paper Corp., Augusta, Me.

Edward J. Albert, President of the Thwing-Albert Instrument Co., was recently elected President of the Scientific Apparatus Makers Association at the Association's 35th annual meeting held recently at White Sulphur Springs, W. Va.

John Ashby is now Vice-President in Charge of Manufacture of the Westminster Paper Co., New Westminster, B. C.

Joseph E. Atchison, formerly of Portorican Paper Products, Inc., is now Senior Project Engineer for Parsons & Whittemore, Inc., New York, N. Y.

Fred G. Barber, formerly of American Coating Mills Div., Robert Gair Co., is now Superintendent of the Gardner Board & Carton Co., Middletown, Ohio.

J. C. Barthel is now Assistant Technical Director, American Cyanamid Co., New York, N. Y.

Oscar C. Brauner, formerly of United Wall Paper, Inc., is now Research Chemist for Hollingshead Corp., Camden, N. J.

Richard K. Britton, formerly of Roy E. Sanford & Co., is now Chemical Engineer in the research laboratory, Chemical Div., The Borden Co., Bainbridge, N. Y.

Frank G. Calkin, Sales Representative of the Oronite Chemical Co., has been transferred from New York City to Atlanta, Ga.

Kenneth Chapman, Shift Foreman, Pulp Div., Weyerhaeuser Timber Co., has been transferred from Longview, Wash., to Everett, Wash.

E. A. Charleton, formerly of the Central Paper Co., is now an executive with H. K. Ferguson Co., Cleveland, Ohio.

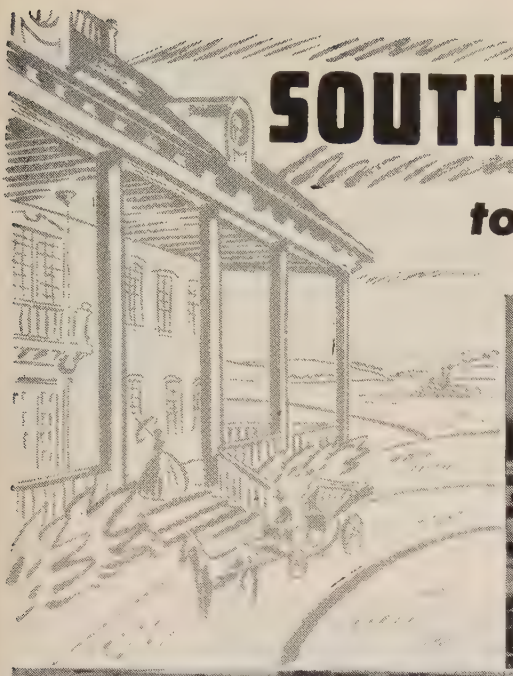
John C. Clapper, Mill Chemist for Hollingsworth & Vose Co., has been transferred from East Walpole, Mass., to West Graton, Mass.

Irving V. Earle, Jr., formerly of the Upson Co., is now Resident Manager of Canadian Glassine Co., Ltd., Quebec, Canada.

Paul B. Fowler, formerly of E. D. Jones & Sons, is now with Texon, Inc., South Hadley Falls, Mass.

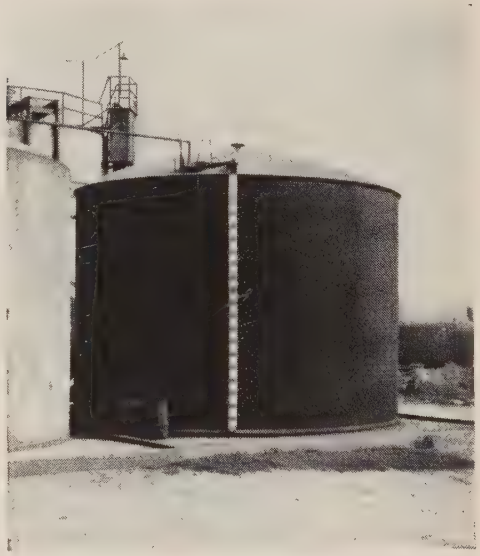
SOUTHERN EXPANSION

to keep pace with demands



Above: General view showing construction during expansion program at St. Regis Paper Company's Cantonment, Fla. plant.

Left: Three 30 ft. diam. by 20. ft. liquor tanks and a 20 ft. diam. by 35 ft. foam tank.



Above: 30 ft. diam. by 20 ft. weak liquor tank built by Chicago Bridge & Iron Company for the St. Regis Paper Company at Cantonment, Florida.

THE pulp and paper industry in the South has been forced to expand rapidly to keep up with the ever-increasing demand for its products. One extensive expansion program recently completed is that of the St. Regis Paper Company at Cantonment, Florida.

Structures built by Chicago Bridge & Iron Company in the St. Regis program include seven new digesters, 10 ft. 6 in. in diam. by 40 ft. high; a blow tank, 24 ft. in diam.; three 30 ft. diam. by 20 ft. liquor tanks; a 20 ft. diam. by 35 ft. foam tank; a Horton accumulator, 20 ft. in diam.; various stacks; and other steel plate equipment such as hot water, surge and sump tanks.

Our facilities for designing, fabricating and erecting steel plate structures are complete. Four large plants in Birmingham, Chicago, Salt Lake City and Greenville, Pa., are strategically located to provide efficient service. Write our nearest office for quotations on tanks and plate work.

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Chicago, 4.....2140 McCormick Building
Cleveland, 15.....2238 Midland Building
Detroit, 26.....1548 Lafayette Building
Havana.....402 Abreu Building
Houston, 2.....2156 C & I Life Building
Los Angeles, 17....1550 General Petroleum Building
New York, 6.....3324—165 Broadway Building
Philadelphia, 3...1642—1700 Walnut Street Building
Pittsburgh, 19.....3257 Alcoa Building
San Francisco, 4.....1538—200 Bush Street
Seattle, 1.....1362 Henry Building
Tulsa, 3.....1645 Hunt Building

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY, and GREENVILLE

In Canada: HORTON STEEL WORKS, Limited, FORT ERIE, ONT.

Karl W. Fries, formerly of the Rhinelander Paper Co., is now Technical Director of the J. G. White Engineering Corp., New York, N. Y.

Daniel C. Gillespie, Sales Engineer for the Dorr Co., has been transferred from Stamford, Conn., to Wilmington, Del.

Fred C. Goodwill is now Assistant to the Vice-President in Charge of Manufacturing, New York, N. Y.

Richard J. Grimm, formerly of the St. Regis Paper Co., is now in the Technical Sales Depart., Stein, Hall & Co., Inc., Cincinnati, Ohio.

W. J. Hall, Project Chemist, Weyerhaeuser Timber Co., has been transferred from Springfield, Ore., to Everett, Wash.

Everett G. Ham, Technical Director of the John A. Manning Paper Co., Troy, N. Y., recently received a reward of merit from the American Society for Testing Materials.

John D. Hankey, formerly of the Oswego Falls Corp., is now a Technical Associate at The Institute of Paper Chemistry, Appleton, Wis.

William D. Haskin, formerly Student at the New York State College of Forestry, is now Engineer for the West Virginia Pulp & Paper Co., Mechanicsville, N. Y.

Lynwood S. Hatch, formerly in Charge of Packaging Research of the Massachusetts Institute of Technology, is now Senior Packaging Technologist for Olin Industries, New Haven, Conn.

Leslie L. Larson, formerly of the Detroit Sulphite Pulp & Paper Co., is now Technical Director of Potlatch Forests, Inc., Pomona, Calif.

David C. Lea, formerly of The Institute of Paper Chemistry, is now Technical Director of Potlatch Forests, Inc., Lewiston, Idaho.

Joseph V. Mason, formerly of Dean Mills, Inc., is now Superintendent of Liberty Paperboard, Inc., Steubenville, Ohio.

Keith W. Max is now Assistant to the Vice-President in Charge of Paperboard Production of the Folding Carton Div., Robert Gair Co., Inc., New York, N. Y.

Richard M. Morris, Jr., is now Technical Superintendent of the Carthage, Ind., and Circleville, Ohio, mills of the Container Corp. of America.

John T. Moynihan, formerly of the National Bureau of Standards, is now Chemist for the Underwood Corp., Burlington, N. J.

Louis L. Mrachek is now Plant Manager of the Mead Corp., Kingsport, Tenn.

R. Paradis, formerly of the Howe Sound Pulp Co., is now Assistant to the Vice-President and General Manager of the Ontario & Minnesota Pulp & Paper Co., Fort Francis, Ont.

Leonard A. Pierce, Jr., is now Resident Manager of the St. Regis Paper Co., Kalamazoo, Mich.

Vernon L. Tipka is now Vice-President of the St. Lawrence Paper Co., Norfolk, N. Y.

Roy J. Schadt is now Resident Manager of the St. Helens Pulp & Paper Co. Div. of the St. Regis Corp., St. Helens, Ore.

James R. Schoettler, formerly of the U. S. Marine Corps. is now a Research Chemist for the Kimberly-Clark Co., Menasha, Wis.

S. C. Slifkin, Technical Consultant, has moved from Palatine, Ill., to 4225 W. Burnham St., Milwaukee 15, Wis.

Clarence L. Smith is now Chief Chemist of the National Container Corp., Jacksonville, Fla.

Harry G. Smolens, formerly of the Becco Sales Corp., is now Consultant on Bleaching for the Pennsylvania Salt Mfg. Co., Philadelphia, Pa.

Reavis C. Sproull is now Director of the Herty Foundation Lab., Savannah, Ga.

Charles R. Stevens, Consultant, is now located at 2017 Sylvania Ave., Toledo 13, Ohio.

F. A. Strovnik is now Assistant Manager of the Eastern Region, American Cyanamid Co., Boston, Mass.

William J. Van Akin is now Vice-President of the Ruberoid Co., New York, N. Y.

Robert J. Van Nostrand is now Midwestern Sales Representative of the Pulp Div., Brown Co., Chicago, Ill.

Kalevi Vesterinen, formerly of the Quebec North Shore Paper Co., is now Engineer for Ensogutzeit Oy., Tainionoski, Finland.

Henry Vranian, formerly Assistant General Superintendent, is now Sales Manager for the Chesapeake Corp. of Virginia, West Point, Va.

A. G. Wakeman is now President of the Coosa River Newsprint Co., Coosa Pines, Ala.

Arthur S. Wells is now Assistant to the Chief Engineer of the Mead Corp., Chillicothe, Ohio.

Virgil W. Westdale is now Test Engineer for the Burroughs Corp., Detroit, Mich.

John E. Wilbur, formerly of S. D. Warren Co., is now Production Engineer for the Container Corp. of America, Carton de Colombia in Cali, Colombia, S. A.

* * *

Roy C. Schadt, Resident Manager, has succeeded Max R. Oberdorfer as the official corporate representative of the St. Helens Pulp & Paper Co. in the Technical Association.

Prabodhchandra J. Patel, Managing Agent, is now the official corporate representative of Gujarat Paper Mills, Ltd., Ahmedabad, India, in the Technical Association.

Charmin Paper Mills, Inc., is the new name of the Hoberg Paper Mills, Inc., Green Bay, Wis., a TAPPI corporate member.

General Package Corp. is the new name of Shellmar Products Corp., Mt. Vernon, Ohio.

* * *

E. L. Crowley has succeeded *J. M. Kahn* (deceased) as the official representative of Infilco, Inc., in the Technical Association.

Industry Notes

Production

The production of paper and paperboard during the first half of 1953 is estimated to have been 13.3 million tons. Of this total, about 6.3 million tons were of paper and 7.0 million tons were of paperboard. Since the production for the first 6 months has averaged about 50% of the total annual production over the period 1946–52 it appears likely that the 1953 annual production should be between 25.4 and 27.7 million tons, and is likely to approximate or slightly exceed the 26.0 million tons produced in 1951.

Wood Pulp

Wood pulp production reached a record high of 1,509,000 tons in May bringing 1953 production through May up to 7,305,000 tons. For the first 5 months of 1953 pulp consumption amounted to 7,782,000 tons.

Wastepaper

Wastepaper receipts totaled 3,561,000 tons during the first 5 months of 1953, an increase of about 380,000 tons over receipts for the same period in 1952. In May receipts were 723,000 tons. Consumption of wastepaper during the first 5 months of 1953 amounted to 3,616,000 tons or an average of 723,000 tons a month. For the same period of 1952 monthly consumption amounted to 640,000 tons.

Planned New Capacity

The APPA survey of industry capacity at the close of 1952 and proposed additions to capacity for the years 1953 and 1954, represents the latest available data on this subject. As in previous years, the data on capacity resulting from the

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Chemicals
For The
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. . . As you know, Solvay is a pretty big company. But I've always found that Solvay service has that personal touch . . . that little something that makes me feel like a valued customer, whether I buy big or small. In a nutshell, Solvay combines the service and facilities of a big company, with the friendly feeling of a small company that really has my interest at heart.

For instance—I always get courteous service from the Solvay sales staff. They always seem to be willing, even anxious, to help me. And as far as delivery is concerned, I get the same prompt delivery as the big fellows.

But probably the most important thing I get is Solvay's "Industry-Wise" Technical Service . . . a specialized, exclusive service that includes technicians who have an intimate knowledge of *my* industry. They give me advice and suggestions—and it costs me nothing.

These are the things that make me count on *Solvay first* for my alkalies."

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Survey of New Capacity (Annual Basis—Tons)

Capacity Increases—New and Rebuilt Machines

Grade of paper	Capacity at end of 1951	Increases during 1952	Capacity at end of 1952	Increases during 1953	Capacity at end of 1953	Increases during 1954	Capacity at end of 1954
Fine	1,326,000	39,000	1,365,000	.....	1,365,000	15,000	1,380,000
Book and groundwood	3,485,000	64,000	3,549,000	28,000	3,577,000	26,000	3,603,000
Tissue	1,409,000	35,000	1,444,000	20,000	1,464,000	34,000	1,498,000
Wrapping and specialties	3,798,000	148,000	3,946,000	475,000	4,421,000	10,000	4,431,000
Newsprint	1,052,000	7,000	1,059,000	34,000	1,093,000	217,000	1,310,000
Miscellaneous	112,000	...	112,000	6,000	118,000	...	118,000
Building paper	1,389,000	...	1,389,000	.....	1,389,000	...	1,389,000
Total paper	12,571,000	293,000	12,864,000	563,000	13,427,000	302,000	13,729,000
Paperboard, including wet machine and building board	13,750,000	287,000	14,037,000	1,084,000	15,121,000	458,000	15,579,000
Total paper and board	26,321,000	580,000	26,901,000	1,647,000	28,548,000	760,000	29,308,000

addition of new papermaking machines were obtained through the cooperation of the Writing Paper Manufacturers Association, which association annually obtains these data from manufacturers of papermaking machines. When the planned capacity reported by the machine manufacturers differed from that reported by the purchaser, however the report of the latter was accepted.

Wood Pulp Capacity by Grades, 1953–55

	As of January 1st 1953	1954	1955
Total wood pulp	19,063,832	20,914,844	21,517,738
Dissolving and special alpha	718,505	1,014,695	1,113,695
Sulphite, paper grades	2,648,085	2,634,180	2,643,450
Sulphite, bleaching capacity	2,012,020	2,004,295	2,004,295
Sulphate, paper grades	9,563,805	10,747,427	11,006,101
Sulphate, bleaching capacity	2,811,554	3,106,279	3,263,754
Soda	472,237	477,562	477,562
Groundwood	2,968,130	3,005,090	3,241,040
Groundwood, bleaching capacity	617,850	623,850	623,850
Semichemical	1,230,795	1,562,885	1,562,885
All other grades	1,462,275	1,473,005	1,473,005

Notes: (1) Tabulated data subsequent to 1952 are preliminary and subject to revision as new programs are initiated, as indefinite programs become definite, or as additional information is developed. (2) Tabulated data include only reasonably assured capacity increases, resulting from improvements, speed-ups, or new plants. Capacity data for the following new mills, scheduled for completion after 1/1/53, are included in the tabulation: The D. M. Bare Paper Co.; Bowaters Southern Paper Co.; Buckeye Cotton Oil Co.; East Texas Pulp and Paper Co.; Ketchikan Pulp Co.; Little Rapids Pulp Co.; Rome Kraft; National Container Corp., Valdosta, Ga.; and Rayonier, Inc., Ga.

Definitions: Annual capacity is the tonnage that could be produced on an annual basis with full use of equipment and adequate supply of pulpwood, chemicals, and labor. The annual capacity of each mill is its reported daily capacity multiplied by the number of days per year that it expects, under normal conditions, to operate, and not necessarily its present operating schedule. All data are in tons of 2000 lb. air-dry weight.

Source: U. S. Pulp Producers Association, Inc.

Reported changes in capacity to produce paperboard were developed with the assistance of the National Paperboard Association resulting in the inclusion of information not reported in the survey of this association; and data on wood pulp capacity were made available by the U. S. Pulp Producers Association.

All papermaking capacity on an annual basis is premised on a 310-day year; wood pulp capacity is reported on the basis of normal full-time operations of the individual mill.

The summary of the report follows:

	Wood pulp, tons	Total paper and board, tons	Paper, tons	Board, tons
		Estimated Capacity		
End of 1951	18,858,000	26,321,000	12,571,000	13,750,000
End of 1952	19,064,000	26,901,000	12,864,000	14,037,000
End of 1953	20,915,000	28,548,000	13,427,000	15,121,000
End of 1954	21,518,000	29,308,000	13,729,000	15,579,000
		Percentage Increase		
1952/1951	+ 1.1	+ 2.2	+2.3	+ 2.1
1953/1951	+10.9	+ 8.5	+6.8	+10.0
1954/1951	+14.1	+11.3	+9.2	+13.3

The results of this survey indicate that this industry will

Survey of New Capacity, 1952–54 (Tons)

Grade of paper	1952 Daily	1952 Annual basis	1953 Daily	1953 Annual basis	1954 Daily	1954 Annual basis
			Capacity Increases—New Machines			
Fine	117	36,270	...	.....	...	...
Book and groundwood	45	13,950	...	.....	...	...
Tissue	105	32,550	15	4,650	85	26,350
Wrapping and specialties	450	139,500	965	299,150	...	...
Newsprint	...	...	110	34,100	700	217,000
Miscellaneous	...	...	20	6,200	...	...
Building paper	...	...	...	.....	...	...
Total paper	717	222,270	1110	344,100	785	243,350
Paperboard	50	15,500	2865	888,150	993	307,830
Building board	250	77,500	50	15,500	...	...
Total paper and board	1017	315,270	4025	1,247,750	1778	551,180
			Capacity Increase—Rebuilt Machines			
Fine	10	3,100	...	.....	47	14,570
Book and groundwood	162	50,220	91	28,210	84	26,040
Tissue	8	2,480	51	15,810	25	7,750
Wrapping and specialties	25	7,750	566	175,460	35	10,850
Newsprint	22	6,820	...	.....	...	...
Miscellaneous	...	...	...	.....	...	...
Building paper	...	...	...	.....	...	...
Total paper	227	70,370	708	219,480	191	59,210
Paperboard	626	194,060	581	180,110	483	149,730
Building board	...	...	...	.....	...	...
Total paper and board	853	264,430	1289	399,590	674	208,940

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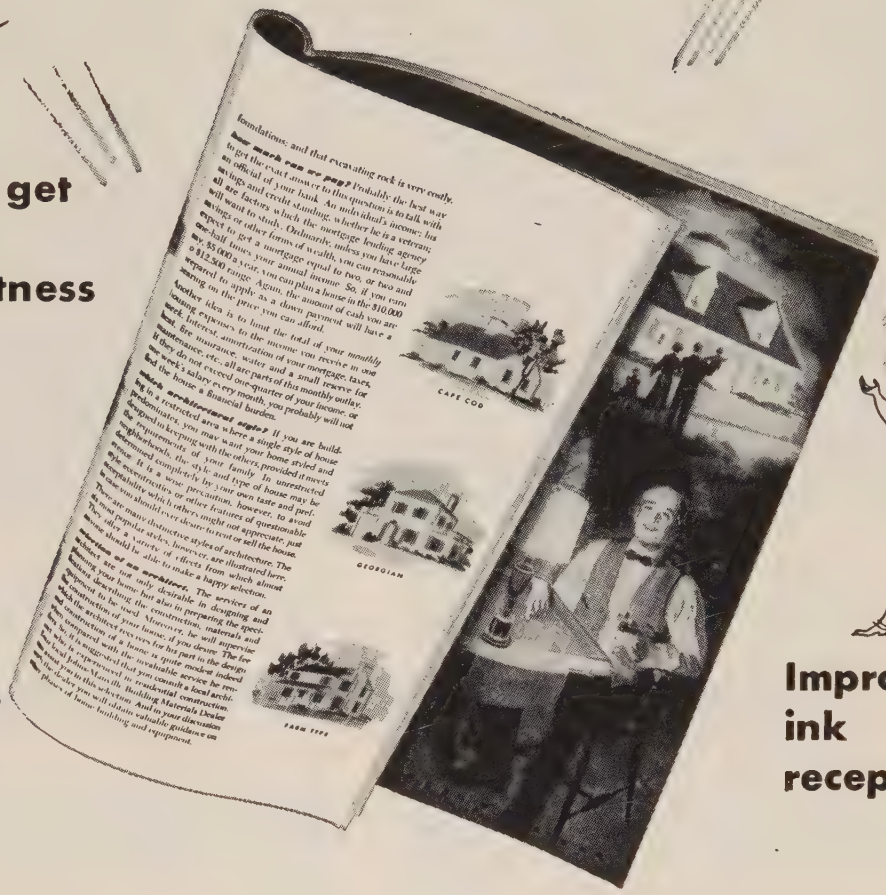

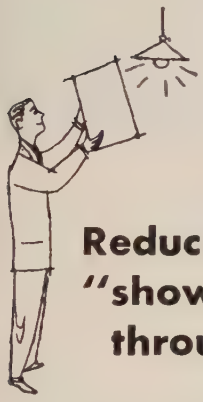

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Because of its unique properties, Celite not only improves the finished sheet but it aids suspension and formation, too. A Celite field engineer will gladly show you how Celite can help you produce better paper at lower cost. For his services, simply write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario. No obligation, of course.

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increase its total annual capacity from 26.9 million tons at the close of 1952 to 28.5 million tons at the end of 1953 and 29.3 million tons at the end of 1954. If present plans for additions to capacity in 1953 are effectuated, the increase of 1.6 million tons will be one of the largest increases ever recorded for a single year.

By the end of 1954 the capacity of the paper industry as a whole will be 8.9 million tons (43.5%) more than at the close of 1946. Paperboard mills alone will have increased their capacity by 5.7 million tons (57.4%), to 15.6 million tons; paper mills will have increased their annual capacity by 3.2 million tons (30.5%) to 13.7 million tons.

In both 1953 and 1954, the major part of the increase in capacity will occur in paperboard, as producers of that commodity expand their capacity by slightly more than one million tons in 1953 and 460,000 tons in 1954.

The manufacturers of paper, as distinguished from paperboard, plan to increase their capacity by 563,000 tons in 1953, of which 344,000 tons would result from the installation of new equipment and 219,000 tons from the rebuilding of equipment on hand. Somewhat more than 80% of this total will result from increases in the capacity of mills producing wrapping paper and specialty boards as those mills increase their annual capacity by approximately 475,000 tons.

No new papermaking machines are planned for by mills in the fine and printing paper fields in either 1953 or 1954. By the improvement of the existing machines, however, fine paper mills will, in 1954, add about 15,000 tons of capacity on an annual basis, and printing paper mills will add capacity amounting to 28,000 and 26,000 tons in 1953 and 1954, respectively.

The present annual capacity of the domestic newsprint industry will, upon completion of present plans, be increased by about 250,000 tons at the end of 1954. At that time the capacity of mills making newsprint will be 1.3 million tons, 23.7% more than at the close of 1952.

If present plans of pulp producers are acted upon, the industry capacity to produce wood pulp will, from the end of 1952 to the end of 1954, increase by 2.5 million tons (12.9%), to become about 21.5 million tons. Of this increase, producers of dissolving grades of pulp will account for 400,000 tons and producers of paper grades of pulp, the balance of 2.1 million tons. In the paper industry the capacity to produce sulphate pulp will undergo the largest expansion, amounting to 1.4 million tons, equal to 66% of the total planned increase for that industry. Although the capacity to produce sulphite and soda pulps will remain virtually unchanged in the period under consideration, the capacity to produce semichemical and groundwood pulps will increase by 332,000 and 273,000 tons, respectively.

Paper and the Insurance Companies

Despite the much-publicized tightness of the long-term money market, manufacturers of paper and kindred products succeeded last year in obtaining 37% more long-term money from life insurance companies and other institutional investors than in 1951, according to "The 1953 Yearbook of Private Placement Financing," published in July by E. V. Hale & Co., Chicago private placement specialists. Thirty-three manufacturers received $207,196,000 from privately placed loans in 1952, as against $150,371,000 to 31 manufacturers in 1951.

Total private placement financing in 1952 amounted to $5,032,803,000, as compared with $5,085,238,000 the year before, the Yearbook states, with 1124 issues in 1952 as against 1256 in 1951. Industrial corporations accounted for $3,249,588,000, or 65% of the total, as compared with $3,564,000,000 or 70%, in 1951.

Integrated paper and pulp manufacturers got the largest share of the money loaned in their field, with 13 loans aggregating $95,530,000, while a manufacturer of pulp exclusively obtained $36,000,000. The latter was Ketchikan Pulp Co., and its issue of $36,000,000 4.25% 20-yr. first mortgage bonds was the second largest in this field; it was taken by a group of institutional investors. Largest loan in the field was $37,500,000 to Bowaters Southern Paper Corp., which took the form of 4.75% first mortgage bonds, due in 1973; the issue was sold to 12 life insurance companies.

Other loans to integrated paper companies included the following: Oxford Paper Co., $10,000,000; St Lawrence Corp., $8,000,000; S.D. Warren Co., $7,000,000; Minnesota and Ontario Paper Co., $6,000,000; Mead Corp., $5,500,000; Champion Paper & Fiber Co., $5,000,000; Rhinelander Paper Co., $4,500,000; Mosinee Paper Mills, $3,500,000; Thilmany Pulp & Paper Co., $2,880,000; Detroit Sulphite Pulp & Paper Co., $2,150,000; Hudson Pulp & Paper Co., $2,000,000; Riegel Paper Co., $1,500,000.

Eight other paper manufacturers obtained $11,566,000. Largest of these loans was $6,000,000 to Ecusta Paper Co., subsidiary of Olin Industries, Inc. This took the form of an issue of guaranteed 3.75% 19-yr. notes, sold to a life insurance company. Others in this group included Gould Paper Co., $2,500,000; Hopper Paper Co. $1,500,000; W. W. Fitzhugh Inc. & Orlando Ave. Corp., $700,000; Beckett Paper Co., $450,000; Stevens & Thompson Paper Co., $216,000; and two loans of $100,000 to Parker Schmidt and Tucker Paper Co. and Hurlbut Paper Co.

Five paper converters borrowed an aggregate of $4,800,000. Largest of these was an issue of $2,500,000 4.25% 20-yr. first mortgage bonds placed for Keyes Fiber Co. with four life insurance companies. Other loans included $1,000,000 to Arkell & Smiths, $700,000 to Imperial Paper and Color Corp., $300,000 to Butler Paper Products Co., and $300,000 to Minerva Wax Paper Co.

Five paperboard manufacturers obtained private placement loans totaling $35,300,000, the largest of which was an an issue of $20,000,000 4.00% 30-yr. bonds of Robert Gair Co., Inc. Second largest was $9,300,000 4.00% 18-yr. first mortgage bonds placed with an institution for Southern Paperboard Corp. Gaylord Container Corp. obtained $3,000,000 through sale of 3.625% 20-yr. notes to a life insurance company, and Manchester Board and Paper Co. and Green Bay Box Co. received $2,500,000 and $500,000, respectively.

"The 1953 Yearbook of Private Placement Financing" is the fifth successive annual edition published by E. V. Hale & Co. (price $100). It obtains its information from all published sources, but principally from a study of the investment portfolios of more than 200 life insurance companies and other long-term investing institutions.

Sweden

Responsible officials in the paper industry appear pleasantly surprised at the present stability of foreign demand for newsprint, wrapping, and other papers, despite payment difficulties in Britain and France. Total exports of paper and board in the first 5-mo. periods have varied from 258,769 metric tons worth 389,352,000 crowns (U. S. $75,144,936) in 1952, to 280,451 worth 248,265,000 crowns (U. S. $47,915,145) in 1953. It is estimated that in 1952 the Swedish paper industry operated at 84% of effective capacity in April, reached a nadir of 60% in August, and in June, 1953, had recovered to 85%. Summer vacations will not be over 3 wk. in duration. Should devaluation occur in Finland, the Swedish pulp and paper market would be seriously weakened, but otherwise the present outlook is good.

During May the Riksdag approved cartel legislation to supplement mandatory registration legislation put on the books in 1946. The new act outlaws resale price cartels and bid cartels and establishes a "Free Trade Board" which will be charged with assuring that cartels are not allowed to adopt methods which adversely affect other sectors of the economy. In spite of punitive provisions, the legislation is

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The Scandinavian paper producers associations decided at their semiannual meetings in the middle of June, to reduce by 10 to 12% the export prices of sulphite and kraft wrapping papers, but not to alter the current prices of fine papers, greaseproof, and glassine. Last January, similar meetings decided not to lower their export prices on board and wrapping papers but to cut by 10% the prices on greaseproof and coarse tissue.

The reductions in chemical pulp prices last Winter and Spring widened the gap between the raw material and the finished paper products, prompting foreign buyers to withhold their purchases. The market for Swedish wrapping and bag paper has been reported unfavorable for many months and the backlog of the few small orders booked with the Swedish exporters were in mid-May said to be hardly sufficient to keep the mills operating for more than 3 wk. Foreign buyers, with the possible exception of British importers, were described in trade journals as anxious only to meet their immediate requirements and purchasing most of their needs from their own domestic papermills which can offer shorter delivery on small orders, even though Sweden's kraft paper productive capacity has been considerably increased since 1947.

The new and substantial price reductions announced by Scansulfit and Scankraft in Goteborg on June 16 and 17 correspond to declines of £ 6:0:0 (U. S. $16.80), per metric ton c.i.f. on sulphite paper, £ 10:0:0 (U. S. $28) on kraft paper, and £ 7:10:0 (U. S. $19) on paper bags except to the United Kingdom, whence a similar reduction had previously been made. The domestic prices of wrapping and bag papers were reduced 6 wk. ago by 100 to 140 kroner (U. S. $19.30–$27) per metric ton to bring them in line with the reduced prices of pulpwood and chemical pulp. Until the export price reductions announced on June 16–17, it was possible for a foreign paper mill purchasing low-cost Scandinavian pulp to undersell the Swedish paper producers in their own market. The price differential had been further increased by the existing high foreign import tariffs on paper which, as a rule, are on an *ad valorem* basis.

The Swedish industry is also operating below capacity but today it is now estimated that the total output of chemical grade pulp in 1953 will be only about 75,000 metric tons below the 2,289,100 recorded for calendar 1952.

The price of *rayon pulp* did not change during the first and second quarters of 1953 following the reduction of £ 2:10:0 (U. S. $7.00) announced in December, 1952, on reservations for delivery during the January–March period. A further reduction of £ 5:0:0 (U. S. $14) has now been made, however on shipments during the third quarter. The c.i.f. price for the normal grade of rayon pulp—the lowest quality—was about 900 kroner (U. S. $173.70) per ton during the first and second quarters. This price has thus been lowered to about 830 kroner (U. S. $160.20) a ton for third quarter delivery.

According to the Swedish foreign trade statistics, an average price of about 940 kroner (U. S. $181.40) a ton has been obtained for exports of dissolving pulp to date this year. This high figure is due to the fact that prices exceeding the 900 kroner (U. S. $173.70) mentioned above, have been paid for many shipments. The price of rayon pulp, following the effected price reduction, has now been brought more in line with that of bleached sulphite paper pulp for which the demand is greater than 2 yr. ago, and should regrade—a practice which has been widespread this Spring. (Conversions APPA.)

Finland

Production and exports of chemical pulp increased slightly in May from the previous month amounting to 82,500 and 60,000 metric tons, respectively, while the foreign demand for newsprint and other paper products continued to hold up well. However, the considerable differential prevailing between domestic production costs and export prices continued to impose a severe financial strain on producers and it is a question how long they can go on producing and exporting at a loss.

The findings of a special committee appointed by the government to study the composition and level of costs in the export industry were made public in May. According to the committee's investigation, based on data supplied by the industry, the average losses per ton at present export prices are as follows: sulphite cellulose 9000 Fmks. (U. S. $39.13); sulphate cellulose, 8825 Fmks. (U. S. $38.37); kraft paper sack 6354 Fmks. (U. S. $27.63); and newsprint, 1291 Fmks. (U. S. $5.61). The grave import of these findings for Finland's economy has given renewed urgency to the government's current efforts to develop a program of cost reduction which will restore Finland's competitive ability on world markets. Thus far these efforts have come to nought because of the difficulty of reconciling the conflicting viewpoints of the economic interest groups which would be affected by such a program. Meanwhile, the export industry is gradually reducing the level of its operations. The reduction has been the greatest in the cellulose branch which is now operating at only about 50% of capacity.

One bright sport in the picture is provided by the increased shipments to the United States of kraft liner board which had taken place this year under long-term contracts concluded at the end of 1952. These shipments are taking place at the rate of 3000–4000 metric tons monthly, and bid fair to result in a permanent addition to Finland's dollar exchange earnings of the order of some $3 million annually. In 1952 total shipments of paperboard to the United States, consisting mainly of boxboard, amounted to only about 5000 tons. According to the Finnish Board Mills' Association, the addition of the shipments of kraft liner under the recent contracts will raise this figure to some 40,000 tons this year. Kraft liner board is produced by one mill in Finland, the Enze Gutzeit plant at Kaukopaa, and approximately three eighths of its present output of 80,000 tons annually is now being exported to the United States. (Conversions—APPA.)

Powell River's Electrical Loop

Powell River's electrical system is a unique one for an industrial plant. It is completely self-contained and requires for its operation such miscellaneous services as snow surveys of its watersheds, and fairly dexterous juggling of water levels in its two main storage systems. Another feature (standard in England and on the European Continent) is its system frequency of 50 cycles rather than the 60 cycles of this continent. The reasons for adopting 50 cycles are apparently buried with the records of long-since departed pioneers.

With the installation of the new electrical distribution system completed, the Powell River Co. has solved one of its more troublesome problems.

The growth of our electrical system from its humble beginnings in 1912 merely reflects the growth that has made this mill the largest single newsprint producer in the world today.

The original installation comprised two 550-v., 2000-hp. hydro units. The present system contains over 100,000 hp. in hydro and steam generation and handles an average plant load of 70,000 hp. In addition, about 25,000 hp. is used in water-driven pulp grinders. This represents a load greater than that of the B. C. Power Commission's Campbell River hydro development serving most of Vancouver Island.

In 1948 the power from the two Stillwater hydro units was transmitted over a single circuit, a 13-mile, 66,000-v. wood pole line to Powell River's Substation 1. From here a 6600-v. tieline connected to another substation containing the four Powell River hydro units and an assortment of steam turbo-generators—all at 2300 v., approximately. Thus 85% of the mill distribution originated from this 2300-v. substation.

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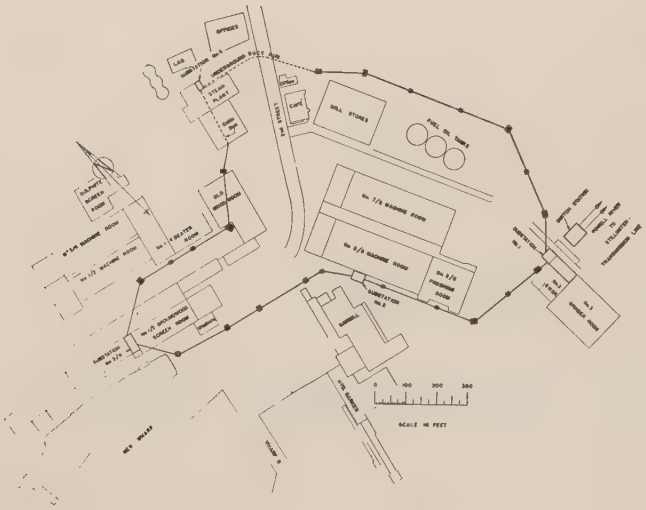

The new Powell River electrical loop

On completion of the major development program of 1948, it became apparent that the old mill electrical system was going to be a bottleneck for any future expansions. It was overloaded and underprotected.

After many studies, a system was finally evolved which would correct the major troubles and do it economically. The scheme consisted of expanding the 6600-v. bus of Substation 1 through current limiting reactors into a one-mile, 6600-v., overhead ring encircling the mill. The route of the ring is shown in the figure. The sole function of the reactors is to limit the short-circuit currents in all parts of the system to reasonable and safe values.

Four new substations were strategically located on the ring to distribute secondary power at 2300 v. The basic principle of the distribution is the approximate balancing of local generation and consumption at each substation, so that normally only about 5000 hp. flows in the ring, i.e., about half the ring capacity

From each substation the power is distributed at 2300 v. for eventual 2300 and 550-v. use in the various departments.

To confirm our design and specifications, the new system was set up in miniature on the General Electric Network Analyzer at Schenectady, simulating transmission lines, the 6600-v. ring, substation transformers, generators, and electrical loads. On the analyzer we investigated the stability of the system and its ability to transfer load for various operating conditions and system arrangements. The studies included "future" conditions involving more generation and loads for future plant expansions. Months of laborious calculations would have been required to approximate even half the information we took off the analyzer in one week.

Studies under "future" conditions visualized two more steam turbines, similar to the Brown Boveri unit just installed, as well as the conversion of the 25,000 hp. of water-driven grinders into an equivalent amount of generators and synchronous motors contained in a sixth substation on the ring.

The analyzer studies confirmed the design as being suitable in every way for our needs. Overload conditions are eliminated. In fact, just about all of the old system is eliminated. Existing breakers in Substation 1, of moderate interrupting capacity, are protected by the current-limiting reactors.

As part of the corrective measures, a new double-circuit steel tower transmission line was built between Stillwater and Powell River since the old single-circuit wood pole line was in need of replacement.

The 6600-v. mill ring is also carried on steel towers with average spans of 120 ft.

In the new substations, oil-filled, metal-clad circuit breakers are used exclusively, and here the second benefit of the current-limiting reactors is secured in the limiting of breaker interrupting duties to standard (and economical) capacities.

A central control room has been established in Substation 5 from which an operator controls all substation breakers, and normally synchronizes and controls all generators, except the two units at Stillwater. Existing synchronizing equipment is being retained at each generator for local emergency control.

To secure quick and coordinated action under both emergency and normal conditions, we have installed an intercommunication system connecting each substation and generation center.

To communicate with the Stillwater plant 13 miles away, carrier current equipment was installed on the 66,000-v. line. This equipment will be suitable for future telemetering and control work and was required upon demolition of the old wood pole line which also carried the original telephone wires to Stillwater.

The excitation and regulation of the four Powell River hydro units was completely revamped. The three small units had been excited by the direct-connected exciter of the large unit, while their own direct-connected exciters were used for miscellaneous mill services such as charging electric locomotive batteries. In the new setup, each generator will be independently regulated and excited, which will yield flexible and selective operation.

Now to return to the 500-v. system. At each department 2300/550 transformer banks have been located. In the old setup, almost all motor circuits were taken directly from the transformer buses to motor distribution centers, thus exposing equipment to full system faults.

To remedy this, we chose for protection of the secondary circuits, a type of equipment that had not, to our knowledge, been used in Canada or the United States before. It has, however, been in wide use in England and Europe for 20 years or more. It is very much cheaper than standard switchgear. It will interrupt very large currents. Practically no mainteance is necessary. The units are very compact and easily installed. The equipment is known as high-rupturing capacity, current-limiting fusegear.

The fusegear is applied as a six-unit or eight-unit assembly directly on the buses of the departmental transformer. From it cable-conduit feeders are taken to the various motor control centers. This part of the program was the most arduous and exacting of all, since it involved every part of the mill and practically every motor. Like the rest of the job, it had to be cut over without interruption of production. The cooperation among our crews was a highlight of the conversion and made possible its successful completion without a hitch.

Champion-International

Thomas L. Stirling has been appointed sales manager. Stirling comes to Champion-International from LaSalle Paper Co. where he was vice-president in charge of book paper sales. Interested primarily in quality papers, Mr. Stirling brings to Champion-International an important record of experience in color research and mill management. Starting during the summer of his college years, Stirling worked at the Mechanicsville mill of the West Virginia Pulp and Paper Co. After graduating from Cornell University, he joined the Du Pont Co. at Parlin, N. J., working as a color matcher in the Duco Div. From there he was transferred to the research laboratory for further study of color problems and in 1928, went to the Philadelphia Paint Laboratories to work on synthetic resins.

At the Naval Stores Div. of the Hercules Powder Co., Stirling had experience as technical serviceman and varnish technician. In 1931, Hercules sent Stirling to their newly acquired Paper Makers Chemicals Corp. with sales territory in Wisconsin and Minnesota and later in Holyoke, Mass. In

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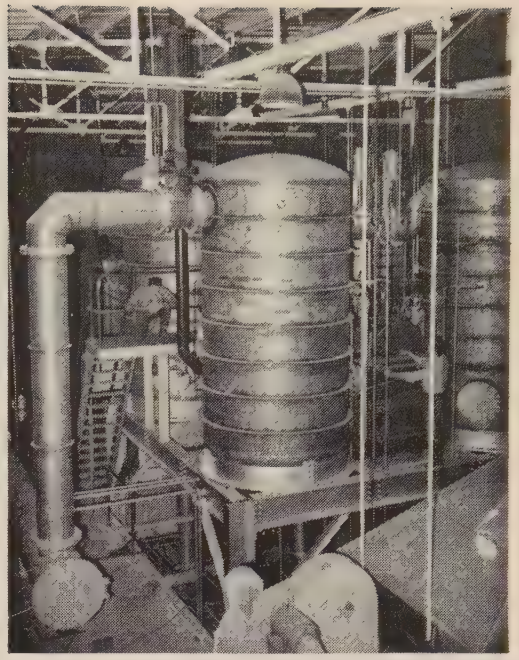

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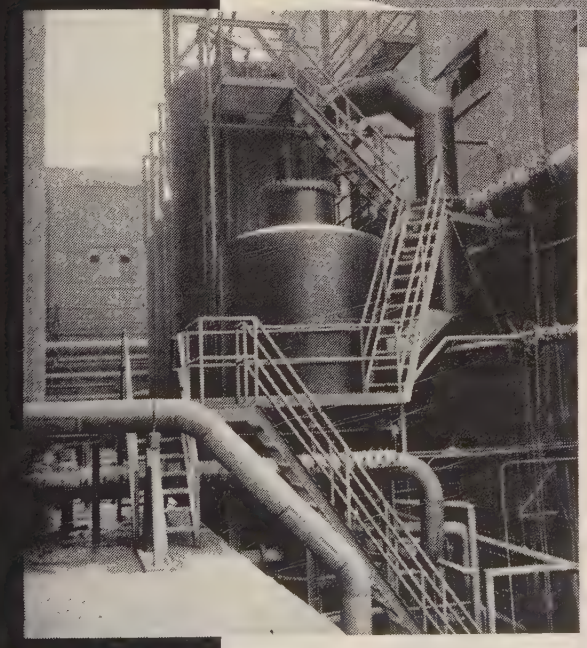

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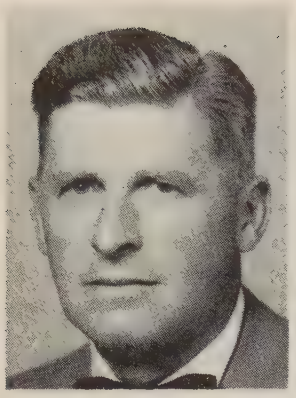
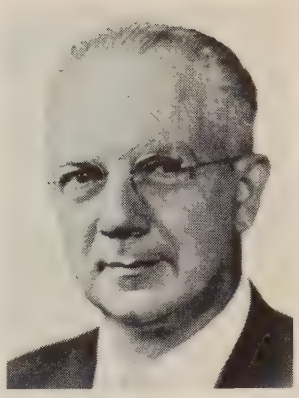


T. L. Stirling, Champion-International Paper Co.



D. S. Bruce, The Gummed Products Co.

1935, he was sent to England as sales manager in Paper Makers Chemicals, Ltd. In England he had the opportunity of visiting practically all of the paper mills in that country as well as a number in Scotland.

After service with the Navy in World War II, Stirling became mill manager of Oxford Miami Paper Co.'s plant at West Carrollton, Ohio, and 3 years later was transferred to Chicago as assistant western sales manager of the Oxford Paper Co.

Gummed Products

The Board of Directors of The Gummed Products Co., Troy, Ohio, has elected Donald S. Bruce as vice-president in charge of research. Mr. Bruce has been head of the firm's research department during the 9 years he has been with the company.

Prior to this he was with Johns-Manville in its research department. Under Mr. Bruce's direction, The Gummed Products Co. has been successful in developing a number of new and improved adhesives. One of these, a by-product of sulphite liquor, is now being used by several of the largest paper manufacturers in the world, under a licensing agreement with The Gummed Products Co.

Through research, all of the firm's products—sealing tape, box tape, gummed printing paper, laminated foils, and many specialty items are constantly improved.

Pulp Mill Use of Logging Residues

A "rapid increase" in pulp mill use of logging residues, cull trees, and mill residues is reported by H. R. Josephson, chief of the division of forest economics of the U. S. Forest Service, according to an item in the July issue of *Forestry Digest.*

Mr. Josephson points out that during the past 10 years, the wood requirement of pulp mills in the United States has increased steadily by an average of about 1,000,000 cords annually to a 1951 peak of nearly 27,000,000 cords. Most of the expanding needs for pulpwood have been met by a larger cut of softwood "growing stock"—trees currently and prospectively suitable for lumber as well as pulpwood and other products. However, changes in economic conditions and the development of improved log barkers and other equipment are stimulating the use of wood leftovers.

In the West, growing stock was drawn on for only 70% of the 4,600,000 cords of softwood pulpwood cut in 1951. About 1,000,000 cords of formerly unused leftovers at sawmills and veneer mills in the Pacific Northwest were converted into pulp. About 400,000 cords of cull trees and other logging leftovers in that area also go into pulp.

In the South, about 84% of the 14,000,000 cords of pulpwood cut in 1951 was produced from growing stock. This includes 10,600,000 cords of pine pulpwood and 1,300,000 cords of hardwoods. About 1,000,000 cords of pine pulpwood were derived from logging residues. A little more than 800,000 cords of pine pulpwood and 300,000 cords of hardwood pulpwood came from cull trees. About 20,000 cords of pine pulpwood were obtained from mill residues. The use of mill leftovers in the South is expected to increase as a result of installation of log barkers and chippers at sawmills.

In the Northeast and Lake States regions about 95% of the 4,300,000 cords of softwood pulpwood and 2,200,000 cords of hardwood pulpwood cut in 1951 came from growing stock.

While acknowledging growing use of leftovers by the industry, Mr. Josephson points out that "in the long run the pulp and paper industry undoubtedly must continue to place its primary reliance upon growing timber crops, with emphasis upon growing desired species in economic locations."

Oregon Budworm

The fight against Oregon's spruce budworm infestations this year began July 1. A total of 350,000 acres are being treated, all but 21,500 of them public-owned lands.

Four flying firms, with about 20 planes, hold spraying contracts. Several lumber firms are cooperating in the project.

This is the fifth year of the spraying program. After this year's spraying, almost 3,000,000 acres will have been treated at an approximate cost of a dollar an acre.

The U. S. Bureau of Entomology and Plant Quarantine hopes that the spraying this year will catch up with the budworm advance.

500 Forest Fires Daily

An average of 500 forest fires a day was reported during 1952, the U. S. Forest Service has announced. However, Forest Service Chief, Richard E. McArdle, cited "an improved record over the past 10 years" and credited the industry-sponsored Keep America Green program and the Cooperative Forest Fire Prevention Campaign with developing "a public awareness to the need for forest fire prevention."

The 188,277 forest fires reported represented an increase of 15% over 1951's fires but was well under the 5-year average.

Fires burned a total of 14,187,325 acres in 1952 compared to 10,781,039 acres in 1951. Again, the burn was below the 5-year average.

The long period of extremely dry weather throughout the country during October and November was blamed for the increase in number of fires and acreage burn. Ninety-four per cent of last year's fires were man-caused.

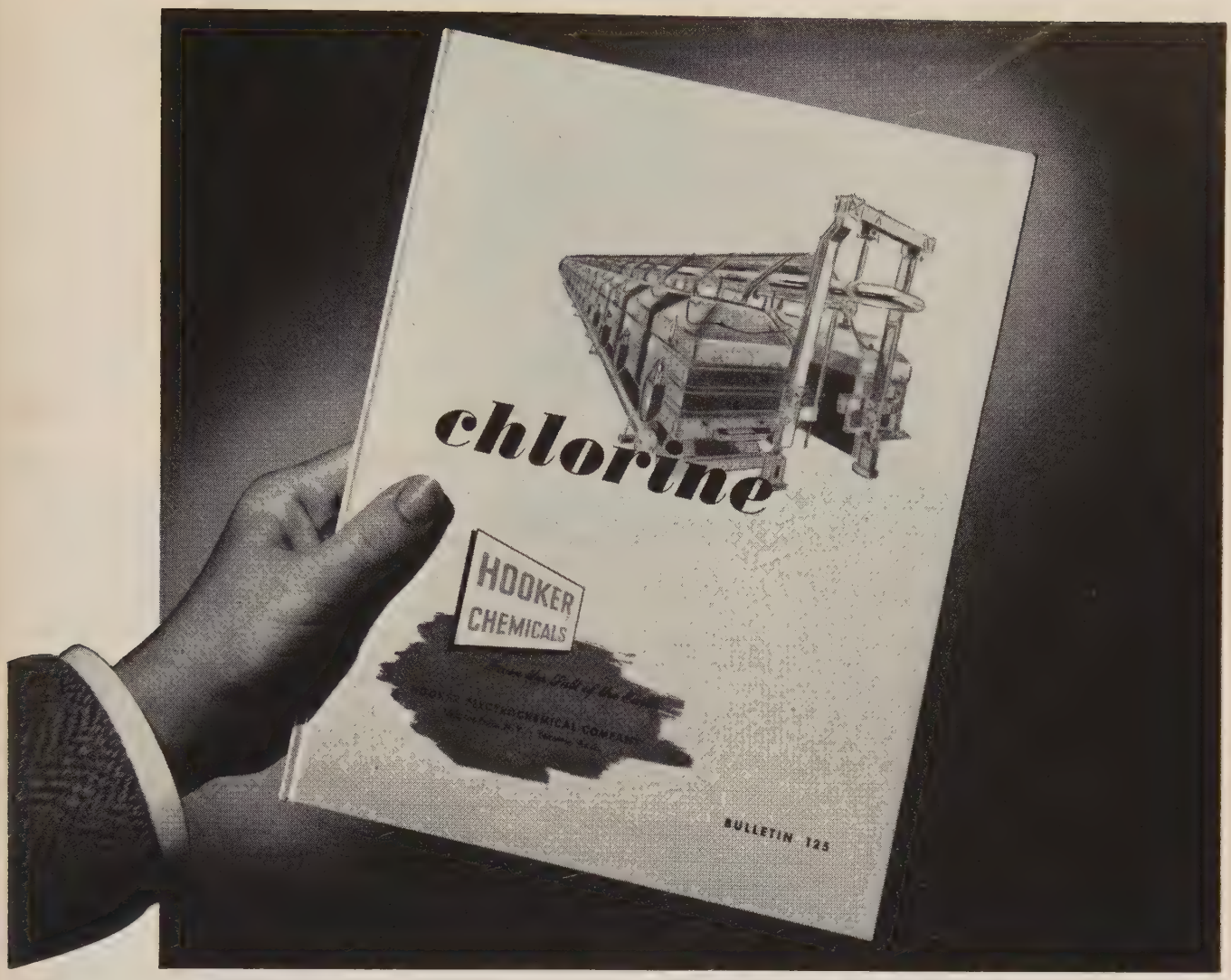
Chemical Debarking

Industry leaders in the Chemical Debarking Research Project meeting at Kingsbury, Me., in June estimated that more than 100,000 cords of pulpwood were treated chemically to simplify bark removal last year in the United States.

The Armstrong Forest Co., Johnsonburg, Pa., first began to use the chemical debarking process in this country about 10 years ago. All bark is removed from a 4 to 6-in. girdle on the tree, and then a 40% solution of sodium arsenite is daubed on the exposed wood with an ordinary paint brush.

Chemical debarking eliminates costly machine peeling of bark. It means steadier work because "chemically treated trees may be peeled during 8 to 10 months of the year, whereas sap peeling can be done for only 8 to 12 weeks," explained Lawrence J. Kugelman of the International Paper Co. The application of the chemical is confined to the sap peeling season. Thirteen pulp and paper companies are taking part in the 2-year-old chemical debarking research project. A staff of from 6 to 8 men is investigating the possibilities of the practice.

"Chemical debarking . . . permits more efficient harvesting and logging practices, and better utilization of the trees and the products obtained from them," declared W. S. Bromley, executive secretary of the American Pulpwood Assn., New York.



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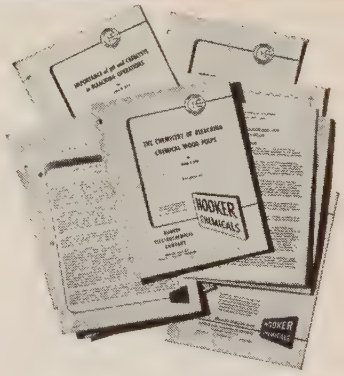

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Nepco

Following a 6-mo. test of lagooning spent sulphite liquor to reduce stream pollution, Nekoosa-Edwards Paper Co. recently placed in operation a large new pond for liquor disposal.

Last Fall the company excavated two test ponds on an island in the Wisconsin River not far from its sulphite pulp mill and piped to these ponds the spent liquor from several of its digesters. In these ponds, the liquor thus lagooned was subjected to sun and air, and it gradually seeped into the soil.

Tests of the quantities of oxygen dissolved in the river water, made for the State Committee on Water Pollution before and after the lagooning, showed an important improvement after the test lagoons began to operate last Fall and during the entire period that they were in use. State and company scientists attributed this betterment to soil bacteria, which they believe consumed much of the wood sugar in the spent sulphite liquor before the liquor eventually found its way into the stream.

Lagooning tests were curtailed last Spring for several weeks to accumulate enough spent sulphite liquor so that the company could test other disposal processes with which it is experimenting. This shutdown time was utilized for excavating a new, much larger pond on the island at a site considered more promising. The flow of spent sulphite liquor was turned into this lagoon recently.

Readings of dissolved oxygen content of the river water have been made at frequent intervals, and further tests in this direction will be conducted throughout the Summer. Also, laboratory examinations are under way, intended to discover just what happens when the spent liquor sinks out of sight into the soil.

Rhinelander

Ten million pounds of dried torula yeast made from the wholesome wood sugars dissolved out of pulpwood chips in the sulphite pulping process, have been shipped from the yeast factory of Rhinelander Paper Co.'s by-product subsidiary. The plant is the only commercial unit in North America manufacturing torula yeast and was completed in 1948 to test a process developed by the Sulphite Pulp Manufacturers' Research League of Appleton for making useful products out of wood solids extract which otherwise would have to flow into the Wisconsin River.

The ten-millionth pound of torula yeast was packaged with appropriate ceremonies in which company executives participated. This package went out as part of a regular shipment to a mixer of poultry feeds in an Eastern state. Poultry feeds are the largest single use of the dried yeast, but it also is widely used in other animal feeds, as an ingredient in prepared human foods, and as a raw material in the manufacture of pharmaceuticals and biologicals.

In its less than $3\frac{1}{2}$ years of operation, the yeast plant has propagated torula yeast organisms in 150,000,000 gal. of liquor from the sulphite pulp mill. The yeast organisms have consumed 20,000,000 lb. of wood sugars from this solution, and thus have kept this quantity of sugar from going into the stream.

For its first 3 years in operation, the plant discarded the resultant desugared wood solids extract. Since last November, a new evaporator plant has been boiling out most of the water and the concentrated extract is sold to other industries as raw material or else is burned in place of coal in the paper mill boilers.

Rayonier

Lowell M. McGinnis has been appointed assistant pulp mill superintendent of the Jesup, Ga., mill of Rayonier, Inc.

Mr. McGinnis tackles a big job at the new $25,000,000 mill, currently under construction, when he moves to his new position October 1. This fifth Rayonier mill will have an annual capacity of 87,000 tons of chemical cellulose, adding 250 tons daily or 20% to Rayonier's dissolving pulp production when operations get under way early in 1954.

With Rayonier since 1940, Mr. McGinnis leaves a job as shift superintendent at the Shelton, Wash., mill.

Mead

Howard E. Whitaker, president of The Mead Corp., is moving his headquarters to the Mead head office at 118 W. First St., Dayton, Ohio. He will continue to spend part of his time in Chillicothe, where the company's operating offices are located.

Arthur S. Wells, plant engineer of The Mead Corp.'s Kingsport Div. for many years, is being transferred to the corporation's General Engineering Dept. in Chillicothe where he will fill the position of assistant to the chief engineer, C. N. Mull. Louis L. Mrachek, who has been construction engineer at Kingsport for the past 2 years, has been appointed plant engineer of the Kingsport Div.

Hurlbut

The Hurlbut Paper Co. has announced a long-range program of research and development of special fiber papers for industry. Almost 3 years' intensive work has already been completed and a progress report includes products at all stages of advancement: in production, pilot-plant, exploratory development, and visionary. Prominent are glass fiber papers for aerosol filtration, chemical process filtration, analytical filtration and laminates; aluminum silicate fiber papers for high heat insulation, filtration, and laminates; and synthetic organic fiber papers for laminates and other uses. Machine production has been started on aerosol and high heat papers and such papers are now being sold by Hurlbut.

In pace with development, and need of increased production facilities, a new fourdrinier machine will be in operation during the third quarter of this year.

North Carolina State College

Eleven of the South's major pulp and paper mills have thrown their support behind a newly developed training and research program in pulp and paper technology in the School of Forestry at North Carolina State College.

Announcement of the industrial interest in the training work was made by Dean Richard J. Preston of the college's School of Forestry and Prof. C. E. Libby, head of the curriculum in pulp and paper technology in the school.

Industrial firms from five Southern states and the executives from each who are now supporting the college program are: James L. Madden, Hollingsworth and Whitney Co., Mobile, Ala.; John L. Riegel, Riegel Paper Corp., Acme; Hans A. Eggerss, Continental Can Co., Hopewell, Va.; Reuben B. Robertson, Champion Paper and Fibre Co., Canton; F. D. Gottwald, Halifax Paper Co., Roanoke Rapids; Hugh D. Camp, Camp Manufacturing Co., Franklin, Va.; E. J. Gayner III, Brunswick Pulp and Paper Co., Brunswick, Ga.; Vertrees Young, Gaylord Container Co., Bogalusa, Ala.; William F. Bowld, Buckeye Cotton Oil Co., Memphis, Tenn.; and G. W. E. Nicholson, Union Bag & Paper Corp., Savannah, Ga.

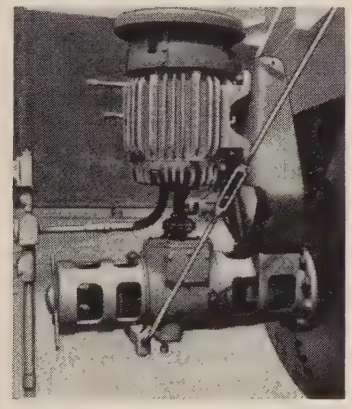
Dean Preston said the industrial representatives have provided the college officials with technical guidance in setting up the new curriculum and have agreed to continue their advisory services to the school.

Following the appropriation of $200,000 for a pulp and paper laboratory by the 1953 General Assembly, officials of the School of Forestry at State College are now working on plans for the laboratory and are pushing other efforts to advance the training and teaching program in pulp and paper.

The plan bears the approval of the Southern Regional Education Board, which views the pulp and paper work as a key factor toward further industrial progress in the South.

FOR STOCK CHESTS—These turbine-type LIGHTNIN Mixers quickly bring stock into fully uniform suspension. Sizes to 500 HP. Factory assembled. Fully guaranteed.

FOR COATINGS, ADDITIVES, chemicals and all-purpose fluid mixing LIGHTNIN turbine and paddle mixers have interchangeable mountings, shafts, speeds for extra versatility. Full range of sizes.



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Research proves you can have both:

Uniform stock consistency, Lower stock handling costs

There are sound reasons why you should demand—and get—*fully uniform* stock right out of the stock chest, without fancy control measures.

When stock is correctly mixed, you shouldn't have to add water to dilute stock in different chests to below-average consistency. You can keep stock consistency high and so get full capacity from each chest.

SIMPLER QUALITY CONTROL—When you are using thoroughly mixed stock, your refining machines can work at their best. A uniform consistency, as high as 6%, can be fed to jordans and beaters, with minimum resetting of machines.

Finally, uniform stock is easier to dilute accurately in the headbox. You can control paper quality closely with fewer safety precautions.

PREDICTABLE RESULTS—You get *fully uniform* stock, at minimum power cost, with LIGHTNIN Mixers. These mixers are designed specifically to provide *complete, controlled uniformity* throughout the stock chest, or in a given volume of the chest. Backed by exhaustive research, and *field-proved,* LIGHTNIN Mixers give you predictable stock consistencies that can be calculated closely.

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British Printing Exposition

The tenth International Printing, Machinery, and Allied Trades Exposition will be held at Olympia, London, England, on July 5-16, 1955. This will be the first postwar exhibition in the United Kingdom devoted to the printing and allied trades.

The exposition is being promoted by the Association of British Manufacturers of Printers' Machinery and is being organized by F. W. Bridges & Son, Ltd., Grand Bldg., Trafalgar Sq., London W.C. 2, England.

Packaging Forum

The 15th annual forum of the Packaging Institute will be held at the Hotel Statler, New York, N. Y., on Oct. 12–14, 1953. Details may be obtained from the Packaging Institute, 342 Madison Ave., New York 17, N. Y.

Ohio Boxboard

Valley Containers, Inc., Youngstown, Ohio, has been purchased from the Ottawa River Paper Co., Toledo, Ohio, by the Ohio Boxboard Co., Rittman, Ohio.

National Container

Harry S. Hemple has been appointed manager of the East St. Louis, Ill., plant of the National Container Corp.

Columbia University

Columbia University, New York, N. Y., will conduct a 15-week course in Package Engineering on Wednesday evenings, beginning on September 30 and continuing to January 20. Details may be obtained from Prof. Frederick C. Winter, School of Engineering, Columbia University, 117th St. and Broadway, New York 27, N. Y.

Among the members of TAPPI who will give lectures are: T. E. Dobbins, American Can Co., Maywood, Ill.; Frank Pocta, Paper Shipping Sack Assoc., New York, N. Y.; Henry W. Stevins, Continental Can Co., Devon, Pa.; Earl R. Stivers, Stapling Machine Co., Rockaway, N. J.; and Charles M. Woodcock, General Foods Corp., Hoboken, N. J.

Paper Balloon

The first balloon was made of paper in 1783 by the Montgolfier brothers. They built a paper bag 35 ft. high, and hung a pot of smoking charcoal under it to see what would happen. The big bag filled with smoke and sailed up into the air, pot and all. They had built the first balloon.

Packaging of Chemicals

Over 17% of all packaging products are bought to wrap up chemicals, a dollar volume exceeding $1.5 billion in 1952. This figure included $256 million for corrugated boxes. The industry consumed $42 million's worth of labels, seals, and tags. Looking ahead, *Business Week* and *Chemical Engineering* predict that by 1960 the packaging market will exceed $2.0 billion. As the chemical industry grows the need for packaging materials will grow with it.

East Texas Pulp & Paper Co.

Construction of the East Texas Pulp & Paper Co. mill at Evadale, Tex., is progressing on schedule with 190 men on the job, which number will be increased to about 450 as delivery of equipment permits. The construction program, together with delivery commitments of the various suppliers, indicates the company will meet its target date calling for initial production late in 1954 and prime quality pulp by Jan. 1, 1955.

After careful consideration of the various bleaching systems used in connection with the chlorine dioxide process, the company has decided on the Solvay system. Its investigation indicates that this bleaching process, together with equipment already ordered for all departments of the mill involving the latest design, best quality, and liberal capacity, will insure producing a top quality chlorine dioxide bleached kraft for the market. Included in this program has been an increase in the size of all washers as compared to the original design, increase recovery capacity, and installation of flat screens after bleaching as well as on the brown stock. The standard pulp specifications have been raised accordingly thus enhancing the company's competitive position. Encouraging results are evidenced by the success in contracting for the sale of pulp. Bids are open for the construction of the effluent disposal canal from settling ponds at the mill to the large swamp area approximately 14 miles to the South.

Bartgis 75th Anniversary

Bartgis Brothers Co. Ilchester, Md., is celebrating its 75th anniversary. A few high lights in the history of the company follow:

1878—The Bartgis Brothers Co. had its beginning when two brothers, C. C. and G. P. Bartgis of Frederick, Md., started a small print shop in Baltimore City. In addition to specialty printing, the firm later imported pill boxes for drug customers.

1892—Moved to 206 Water St., Baltimore, where the manufacture of boxes was continued.

1904—The year of the Baltimore fire which destroyed a large portion of the city's business district including the Bartgis plant. The Bartgis Brothers Co. soon reopened their business at 6–8 S. Green St., Baltimore. More space and better facilities were acquired for the manufacture of folding cartons.

1923—After the death of Wm. P. Bartgis, the company was acquired by E. H. Lupton under whose management the business continued to grow, and within 3 years moved to larger quarters at Bush and Hamburg Sts. in South Baltimore.

1928—The company acquired the present site of 106 acres and buildings at Ilchester, Md. In this location, the company's first paperboard machines were installed.

1942—After the addition of much converting equipment, the need for greater capacity of paperboard was apparent, and in this year the company installed its No. 2 paperboard machine which more than doubled the capacity.

1945—Controlling interest in The Bartgis Brothers Co. was purchased by The New Haven Pulp and Board Co. The late W. R. Shaffer, founder of The New Haven Pulp and Board Co., was elected chairman of the Board of The Bartgis Brothers Co. J. S. Miller, president of The New Haven Pulp and Board Co., was elected president.

1948—The company embarked upon an expansion program which included the construction of a new power plant, improvements to the paperboard machines, and additional carton plant equipment including a new five-color rotary press and modern high-speed gluing equipment.

The Bartgis Brothers Co. has continued to expand in order to meet the increased demands of its customers. During the past 5 years, it has established an effective Quality Control Dept., enlarged its Package Engineering Dept., and made further additions to plant and equipment. The company is now installing another five-color rotary press to meet the increasing demand for fine quality multicolored cartons.

Some Sources of Market Data

"Thomas' Register of American Manufacturers," Thomas Publishing Co., New York.

"Poors' Register of Directors of the United States and Canada," Poors Publishing Co., New York (Annual).

American Business Directories, Department of Commerce, Industrial Series No. 67, Government Printing Office, Washington, D. C., 1947.

"Who's Who in Commerce and Industry," A. N. Marquis Co., Chicago, 1947.

"Directory of New England Manufacturers," George D. Hall Co., Boston, Mass. (Annual).

Your Production by

SIZE PRESS COATING

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PENFORD GUMS

starch hydroxy ethyl ethers U.S. Pats. Nos.

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Many mills are now upgrading their production by improving smoothness, brightness, opacity, and printability with pigmented size press coatings containing PENFORD GUMS.

Sheets ranging from bleached kraft and sulfite to high rag content specialties in all weights are now being improved by size press applications. Coatings of from 4 pounds to 16 pounds per ream are applied. PENFORD GUMS used are equally satisfactory with clay, titanium dioxide, carbonates, and talc. These sheets look *BETTER*, feel *BETTER*, print *BETTER* and frequently cost less.

Your regular size press equipment can usually be used without changes or additional equipment.

Coatings up to the usually applied 6–8 pounds per ream are water-resistant, and coated board may be water finished at the calender stacks. For special uses, resins, latices, waxes, etc. may be incorporated as necessary.

The exceptionally high adhesive value and non-migrating nature of PENFORD GUMS allow one to meet the highest pick tests necessary.

We would be happy to work with your technical department on this new use of the Penford Gums as well as on their previously established applications in straight starch surface sizings, internal sizing, and general adhesive applications.

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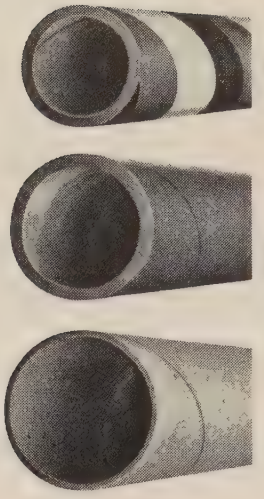

PQ Silicate Adhesives and paper tubes go together

Where maximum strength, rigidity and economy are required, PQ Silicate is the adhesive preferred. Paper tubing laminated with silicate is bound tightly (avoiding "dog ears"). PQ Silicates have the right wetting and penetrating properties; the viscosity is adjustable for your equipment.

Tubes, fibre drums and cans are stronger and firmer because of the rigid film within the tubing wall. Let us study your laminating requirements to suggest how a PQ Silicate may help your quality or production.

• PQ Silicate Adhesive Processes are used in the fabrication of corrugated and solid fibre board, wall board and acoustical board.

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PQ Silicates of Soda
METSO DETERGENTS

State Directories of Manufacturing, usually published by the state Departments of Commerce or Development Commissions.

"Industrial Research Laboratories of the U. S.," Callie Hull, National Research Council, Washington, D. C., 1946.

"The 1947 Census of Manufactures," Department of Commerce, Bureau of the Census, Government Printing Office, Washington, D. C., 1947.

"The 1948 Census of Business," Department of Commerce Bureau of the Census, Government Printing Office, Washington, D. C., 1948.

"Sales Management—Survey of Buying Power," May 10, 1953, Sales Management, 386 Fourth Ave., New York 16, N. Y. ($4.00).

"Consumer Markets, 1952–1953," Standard Rate & Data Service, Inc., 1740 Ridge Ave., Evanston, Ill. ($10).

"Market Research Sources, 1952–53."*

"Small Business Aids Series."*

"Check List for the Introduction of New Consumer Products."*

"Check List for the Introduction of New Industrial Products."*

Hoberg—Charmin

The name of Hoberg Paper Mills, Inc., has been officially changed to the Charmin Paper Mills, Inc. The change was adopted in order to more closely identify the company with the Charmin and Evergreen lines of paper products manufactured by the company. There will be no change in either company policies or products. The new name was approved by stockholders and the company's board of directors June 23.

The original John Hoberg Co. was founded in 1892 at Kaukauna. Equipment of the original mill consisted of one 72-in. water-powered paper machine and two converting machines.

In 1895 the firm moved to Green Bay after accepting a site on the East River offered by the Green Bay Business Mens' Association. The group lent financial backing and other incentives to establish the first tissue mill in Green Bay. The decision to move to this area was the forerunner of an industry that would one day make Green Bay one of the leading cities of the world in the manufacture of personal use papers. Today the firm's division A properties are on the original site along the north banks of the East River.

There were 35 persons on the payroll in 1895. Today, Charmin Paper Mills employs over 1000 persons at its three plants—division A, which has converting facilities for all Charmin and Evergreen products plus five paper machines; division B includes the sulphite mill, laboratory, and two paper machines; Little Rapids, south of West DePere, purchased to insure the firm a constant source of groundwood used in the manufacture of its papers.

The 10-year period between 1932 and 1942 marked the most important milestone in the development of the company. As sales continued to climb, greater emphasis was placed on brand simplification. The firm has used the Charmin brand name for its products for the past quarter century.

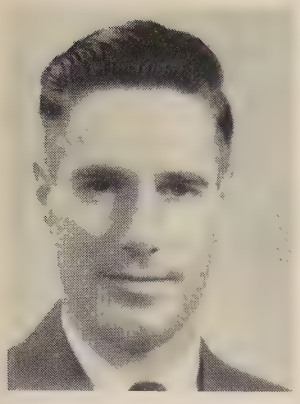
Recent improvements in Charmin Paper Mills include a new powerhouse and paper machine at division A, and both multimillion dollar projects and stream barking facilities at division B. The company is currently in the process of constructing a $2,500,000 torula yeast plant.

The paper industry today is the sixth largest nationally, with Charmin ranking among the top four producers of personal use paper products. The company produces 225 tons of paper daily.

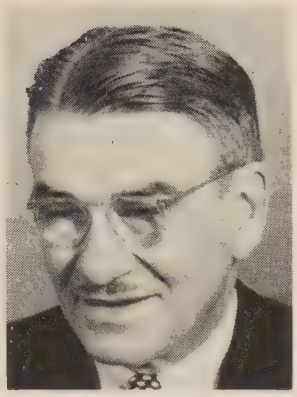
Charmin Yeast Plant

The appointment of Walter Jacobs as yeast plant super-

* U. S. Department of Commerce, Washington, D. C.



Walter Jacobs, Charmin Paper Mills, Inc.



E. A. Charlton, H. K. Ferguson Co.

intendent of Charmin Paper Mills, Inc., Green Bay, Wis. has been announced by J. M. Conway, president and general manager of the firm. Jacobs will work on the plant design and selection of equipment to be used in the Charmin torula yeast plant which will manufacture edible yeast as poultry feed from spent sulphite liquor. Jacobs will act as project engineer during construction of the plant, later taking charge of all production when the plant begins full-scale operations late in 1954.

Since 1951 Jacobs held a similar position with the Lake States Yeast Corp., a subsidiary of the Rhinelander Paper Co. Previous to this, he was employed by the Sulphite Pulp Manufacturers' Research League and was engineer-inspector during the construction of the Lake States plant. When the pilot plant was completed he was made superintendent by the league. He served in the same capacity after the plant was purchased by Rhinelander in 1951. Jacobs is a native of Appleton, Wis.

Final space requirements for the yeast plant have been resolved and consulting engineers are preparing plans and specifications for a two-story building 165 ft. long by 82 ft. wide by 40 ft. high. The building will be erected on the company's division B property at Eastman Ave. and Quincy St. When completed the Charmin plant will be the largest torula yeast installation in the world.

Contracts for major equipment for the plant, including yeast separators, driers, and blendors are expected to be awarded soon.

Work on the 3150-ft. tunnel connecting both Charmin divisions is progressing ahead of schedule. Chapel and Amundson, Green Bay contractors, are in charge of this phase of the antipollution project. Contracts were recently awarded the Zeise Construction Co. to build access houses over the tunnel. Another local firm, The Reliable Painting Service, will paint exposed steel within the tunnel.

H. K. Ferguson

E. A. Charlton, associated as an executive and consultant with the paper industry for 35 years, has joined the H. K. Ferguson Co., engineers and builders with headquarters in Cleveland. O. F. Sieder, executive vice-president and general manager, who made the announcement said Mr. Charlton will serve in an executive capacity.

Mr. Charlton has been president and general manager of Central Paper Co., Inc., Muskegon, Mich., the last 3 years. He was vice-president in charge of operations for International Paper Co. and Canadian International Paper Co., for many years.

Mr. Charlton went into private practice as a pulp and paper consultant in New York City from 1941–50. He also has been general manager of Crossett Paper Mills, Crossett, Ark., manager of the New York World Paper Mills, New York

Take a look—a close look—at the picture. It is a greatly magnified section of the damp edge of a felt.

Note the deterioration of the woolen threads—practically destroyed by the bacteria in the water.

Because the edges beyond the roll faces have less opportunity to shed water than the center of the felt which goes thru the roll nips, an ideal bacterial breeding ground is created.

The corrective! Orr An-bac felts—the type of felt that contains bacteria destroying chemicals.

The use of Orr An-bac felts has been extending the felt life-span and making friends for years. They could do as much for you.

Give Orr-An-Bac felts that opportunity.

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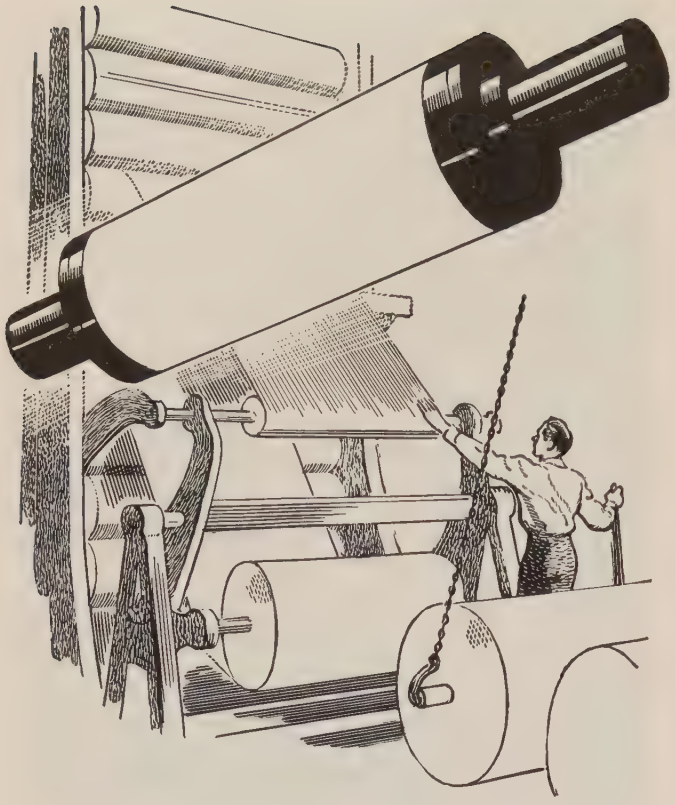

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Leading mills from coast to coast have proved that Butterworth Calender Rolls out-perform other rolls in the same stack . . . under the same operating conditions. Give longer life before turning down or refilling. Produce smoother, uniform finishes that mean a competitive advantage.

Try Butterworth Calender Rolls in your mill. Check their extra service life, their superior calendering. They're made to your specifications, and pre-tested for hardness, smoothness and density. Locked on the shaft under terrific pressure, they cannot slip or come loose. Taper wedges hold forged steel head and shaft rigidly together.

Butterworth Calender Rolls are made for every calendering need—coated stock, super-calendering, glassine or embossing. Furnished new or refilled. Let us quote on your requirements.

For full information, write or call H. W. Butterworth & Sons Company, Bethayres, Pennsylvania – 187 Westminster Street, Providence, R. I. : : 1211 Johnston Building, Charlotte, N. C.

Butterworth
CALENDER ROLLS

City, and paper mill superintendent of Brompton Pulp & Paper Co., East Angus, Quebec, Canada.

Mr. Charlton was graduated from McGill University with a chemical engineering degree and is a licensed professional engineer of New York State.

PERMUTIT

The Permutit Co., 330 W. 42nd St., New York 36, N. Y., has issued an 8-page bulletin (3869) on its Package Water Conditioning Plant.

CYANAMID

The Southern Regional Office of the American Cyanamid Co. has been moved to 161 St. Michael St., Mobile, Ala. K. E. Youngchild is local manager. Associated with him are: A. R. Skelton and John L. Dillon.

American Cyanamid Co.'s Calco Chemical Div. will build a 14 million dollar titanium dioxide plant on the outskirts of Savannah, Ga. The plant will be completed in 1955. Robert & Co. of Atlanta, Ga., will design the plant.

JOHNS-MANVILLE

John E. Begert has been appointed vice-president of the Johns-Manville Products Corp. He will be responsible for the coordination of the company's research findings.

Edward D. Flavin has been appointed manager of the newly formed Public Utilities Section of the Johns-Manville Corp.

Clarence C. Simoni has been appointed New York district manager of the Johns-Manville Industrial Products Div.

HOOKER

Hooker Electrochemical Co. is distributing 50% strength liquid caustic soda from new storage and distributing facilities located at Hudson Tank Storage, Weehawken, N. J. The storage of one million gallons will serve the New York-New Jersey area.

CHEMICAL SHOW

The 8th National Chemical Exposition will be held in the Coliseum in Chicago, Ill., on Oct. 12–15, 1954.

GRAVER

The common stock of Arthur D. Little, Inc., Cambridge, Mass., previously held in trust for M.I.T. has been purchased by its employees' retirement trust fund for $1.3 million.

NATIONAL STARCH

National Starch Products, Inc., has announced a new precoating material "Resyn 80N782" to smoothen the surface of rough and gray chipboard, to produce a better printing surface.

The OQMG has recently awarded a research and development contract to make an improved adhesive for packaging of Quartermaster items for overseas shipment. The new program calls for an adhesive that will seal closures on all presently known types of waterproof barrier materials, case liners, fiberboards, and coated papers. The sealed closures must be able to withstand the effects of exposure to temperature of −60°F. and a relative humidity range of 20 to 90%. The work will be done at the new Alexander Laboratories located in Plainfield, N. J.

M.-C. & S.

Merritt-Chapman & Scott Corp. has purchased the Fitz Simons & Connell Dredge & Dock Co. of Chicago. At present M.-C. & S. is building a 500-ton per day paper mill near Valdosta, Ga., for the National Container Corp.; an extensive newsprint project at Taweran, New Zealand, entailing construction of 75,000 tons per year of paper and a 37,500-ton per year sulphate pulp mill; and a 25,000 ton per

year paper mill at Hadera, Israel, which will be the first of its kind in the Middle East to produce printing and writing paper as well as kraft multiwall bag paper.

G.E.

The General Electric Co., Schenectady, N. Y., has issued a new edition of its "Measuring Equipment Catalog" (GEC-1016A) for laboratory and production testing.

G.E. will build a $5 million plant at Bloomington, Ill., to manufacture general-purpose controls for industrial use.

John Waldron

John Waldron Corp., P.O. Box 791, New Brunswick, N. J., has issued a new bulletin (No. 1004) on its "Reverse Roll Coater."

Appleton Woolen

Jack E. Johnson, representative on the West Coast for the Appleton Woolen Mills, has retired. He is succeeded by C. W. Felt of Seattle, Wash., who will call on paper companies in California, Oregon, Washington, and Idaho.

Columbia-Southern

Brooks M. Dyer has been appointed assistant director of sales for Columbia-Southern Chemical Corp., Pittsburgh, Pa. William Carpenter has succeeded him as acting district sales manager at St. Louis, Mo.

Newcomb-Detroit

Leonard Allman, formerly of the J. O. Ross Engineering Co., has been appointed sales director of the Pulp and Paper Mill Equipment Div. of Newcomb-Detroit Co., makers of air handling systems.

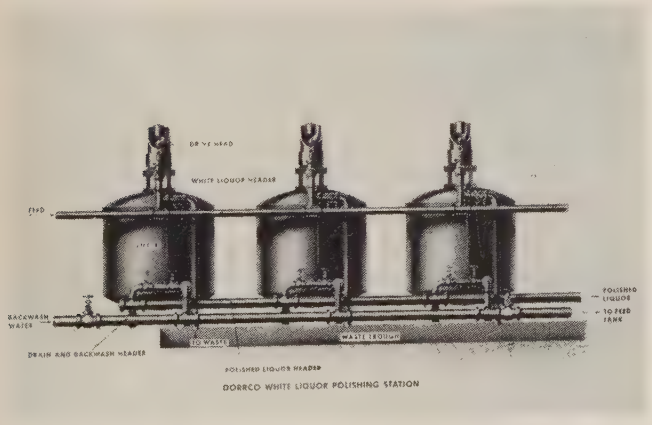
Reliance

Reliance Electric & Engr. Co. has appointed three engineers to district offices: Donald L. Peterson to Cleveland, David H. Rush to Buffalo, and John E. Harger to Detroit.

Dorrco

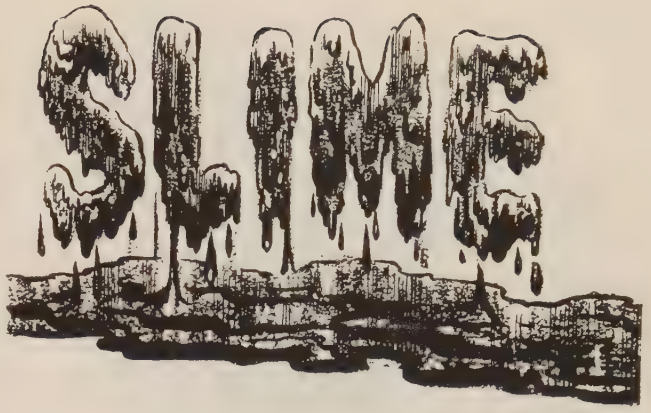
Elliott J. Roberts has been appointed technical director in charge of research, development, and the Westport Mill of the Dorr Co., Stamford, Conn. Bryant Fitch succeeds him as director of research. Frank A. Downes has retired as vice-president in charge of research.

The Dorr Co. has announced the availability of its "Dorrco White Liquor Polishing Station." Its function is to provide a final polish to white liquor clarifier effluent which is applicable wherever pulp brightness is a factor.



Dorrco white liquor polishing station

According to Dorr, a brilliantly clear cooking liquor is produced by the removal of colloidal impurities too fine for economical gravity settling. A uniformly brighter pulp is



There's only one sure way to keep slime damage at a minimum, and that's...

KEEP CLEANING IT OUT!

You can keep slime out of your mill's system by facing the fact that the job is one of good housekeeping! And you can keep cleaning it out on a sure and economical basis with Magnus Slime Remover.

This powerful alkaline cleaner with built-in ultra-fast wetting action digs deep down into slime deposits everywhere in the system...even in spots not reached by ordinary cleaning methods. It loosens the bond of the slime to metal and other surfaces, and completely removes the deposits. It also kills the fungi and bacteria that build slime.

Make It Routine

If you use Magnus Slime Remover on a regularly scheduled cleaning routine, you can keep slime damage virtually at the vanishing point in your mill. And because of its ease of application, the elimination of most hand cleaning operations and its thorough action, you'll find that the cost of keeping slime from accumulating in all parts of the system is lower than by any other method.

LOOK IT UP IN THE PAPER MILL HANDBOOK

On pages 4 to 8 and 19 to 22 of the Magnus Paper Mill Cleaning Handbook you'll find full details on Slime Control with Magnus Slime Remover. Write for a copy of this manual.

magnus

MAGNUS CHEMICAL CO., INC.
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In Canada: Magnus Chemicals, Ltd., Montreal
Service Representatives in Principal Cities

ELMENDORF TEARING TESTER

Measures the internal tearing resistance of paper, textiles and sheet materials in gram-centimeters. Dependent upon gravity for its operation; the readings must be correct. Any two Elmendorfs anywhere will perform alike under like conditions. Tearing resistance is the most practical test for predicting wearing quality. It is a measure of service. TAPPI, ASTM and Federal Standard. Made in many capacities.

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107

OPEN UP AND CUT BAGASSE FIBER WITH TAYLOR-STILES EQUIPMENT

If you use long bagasse fiber for pulp, paper, or wallboard, you'll find use for the efficient and powerful bale breaker.

If you use short bagasse fiber, ask us to tell you about the bale breaker and fiber cutter shown in the picture above.

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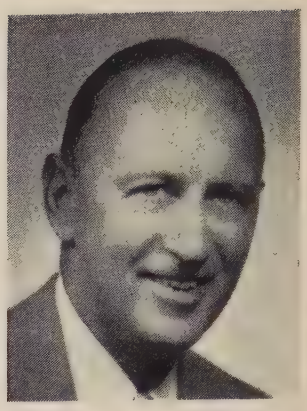
48 Bridge Street **Riegelsville, N. J.**

J. B. Kohler, consulting engineer



G. B. Martin, F. C. Huyck & Sons

thereby assured, regardless of variations in settling and slaking conditions in the recausticizing operation. Finely divided carbon particles which occasionally result from incomplete combustion in the recovery furnace are also eliminated. While this is of particular concern to producers of bleached and dissolving pulps, the assurance of a cooking liquor of uniform purity and clarity is of interest to every producer in terms of better over-all operations.

Hunterlab

Hunter Associates Lab., 5421 Brier Ridge Rd., Falls Church, Va., has issued a 10-page bulletin on "Color, Gloss, Reflectance, Opacity, Turbidity, and Haze."

Kohler

John B. Kohler, formerly president and chief engineer of the Kohler System Co., has opened offices at 218 Woodstock St., Crystal Lake, Ill., to provide consulting services to the paper, paper converting, and printing industries. He specializes in special machine design, and process and operating problems. Mr. Kohler is the inventor of the Kohler System of unwinding and rewinding, with full-speed roll change. He has wide experience in the design and operation of equipment for coating, waxing, laminating, sensitizing, foil mounting, and supercalendering.

Container Laboratories

Container Laboratories has established an engineering office at 1519 Connecticut Ave., N. W., Washington, D. C., to deal with package engineering problems.

Hygrotester

Hygrotester, Inc., 101 Henry St., Brooklyn, N. Y., has recently circulated letters of commendation for its moisture tester from the Newton Falls Paper Co., Foster Paper Co., and the Racquette River Paper Co.

Celli-Flynn

Celli-Flynn, architects and engineers, have established new offices at 335 Shaw Ave., McKeesport, Pa.

Koppers

The Chemical Div. of the Koppers Co., Pittsburgh 19, Pa., has issued a 32-page bulletin (C-3-180) on "Polystyrene Emulsions."

Huyckfelts

George B. Martin has been appointed a sales representative for papermakers' felts and jackets by F. C. Huyck & Sons, Rensselaer, N. Y. Mr. Martin, formerly of the General Dyestuff Corp., will represent the company in New York State, a territory formerly covered by Curtis F. Haskins, who will now devote his effort to Vermont, New Hampshire, and Western Massachusetts.

Du Pont

E. I. du Pont de Nemours & Co., Inc., has transferred two of its Chicago Dyes and Chemical Div. sales representatives: A. C. Sutherland will be located at Appleton, Wis., and B. F. Vaughan in Kalamazoo, Mich.

Walter F. Coleman has been appointed assistant manager of the Chicago District sales office of Du Pont's Electrochemical Dept.

The first tank car of hydrogen peroxide made by a new non-electrolytic process was shipped recently from Du Pont's Memphis, Tenn., plant.

Static

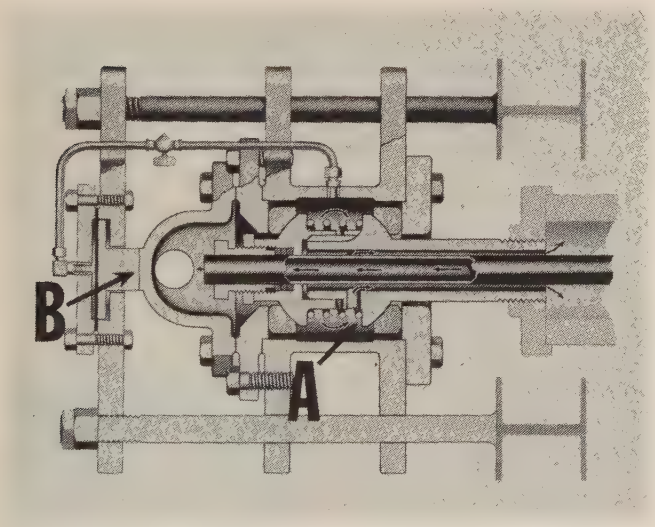
J. F. Doyle Co., 1220 W. 6th St., Cleveland 13, Ohio, is marketing an antistatic aerosol called "Statikill" which can be sprayed on paper passing through printing presses to prevent papers from stitching together. It is said to be effective on folding machine rollers, ruling machines, and similar equipment and acts as a good antistatic belt dressing on drive mechanisms. Du Pont's "Freon" fluorinated hydrocarbon is used as a propellant in the aerosol.

Louis-Allis

The Louis-Allis Co., Milwaukee 7, Wis., has issued a new 16-page bulletin (No. 1450) covering its line of d.c. motors $^1/_2$ to 300 hp. and d.c. generators, $^3/_4$ to 250 kw.

Johnson Corp.

The Johnson Corp. of Three Rivers, Mich., has announced a new development which can considerably reduce the power requirements of rotary joints used on cylinder driers. Called the Johnson Joint Automatic Load Compensator, this new device offers a means of counteracting the pressure on the sealing member of the Johnson Joint, thus reducing friction load and increasing service life.



Johnson joint automatic load compensator

This new compensator takes the form of an attachment, which is supported by the same rods that support the Type L Johnson Joint, and which is locked in position by adjusting nuts on these rods to exert a force against the joint body. It houses a flexible metal diaphragm and a heavy metal plunger; pressure from the Johnson Joint, admitted to one side of the diaphragm, is transmitted by the plunger to act upon the joint body.

The accompanying figure shows the basic principle of operation. Pressure within the joint exerts a sealing force represented by "A." This same pressure is transmitted through connecting tubing to exert a force, represented by

They are probably all tempting to you, and they all have one thing in common — they all have been wrapped by *heat seal methods.*

The economies and advantages of heat seal methods are well known. ARCCO offers paper, film and foil converters, a commercially proven line of specialty heat seal coatings and adhesives. They are available in emulsion, solution, and hot melt types and can generally be applied with your present equipment.

They can be engineered to possess various characteristics to suit your particular requirements. An ARCCO engineer will be happy to work with you. Write for data sheets.

ARCCO 1044-29A — Universal Heat Seal Coatings for Glassine, Paper, Aluminum Foil and Cellulose Acetate. Data Sheet C-66.

ARCCO 1044-31 — Heat Seal Coating for Candy Bar Wraps. Data Sheet C-66.

ARCCO 716-6 — Heat Seal Spot Coating for Waxed Glassine. Data Sheet C-66.

FOILAC 1261-12C — (Clear) Solution Coatings for Metal Foils. Data Sheet C-61-R.

ARCCO 1044-27A — **ARCCO 1044-27B** — Heat Seal Greaseproof Resin Emulsion Coatings. Data Sheet A-43.

ARWAX 717-46B — Hot Melt — paraffin wax additive for improved heat seal and improved water-vapor resistance. Data Sheet C-71.

ARCC

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RESIN EMULSIONS, SOLUTIONS AND HOT MELTS FOR ADHESIVE BASES, BINDERS, COATINGS, SIZES AND SATURANTS

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Check these Superior Features of
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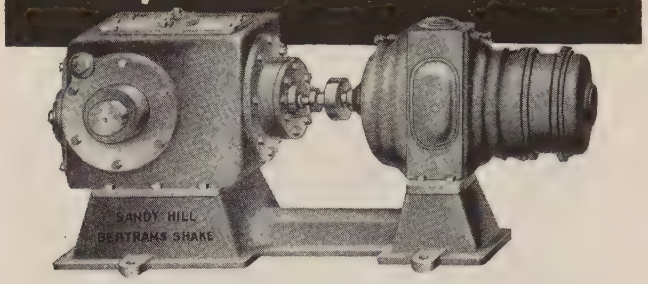

- The last word in Fourdrinier Shakes, the Sandy Hill BERTRAMS gives a perfectly horizontal motion. It is the only shake that gives a full harmonic motion.
- The length and number of strokes can be varied from zero to maximum while the machine is in full motion, resulting in extremely accurate control of sheet formation on the wire.
- No friction problem because all working parts are totally immersed in oil.

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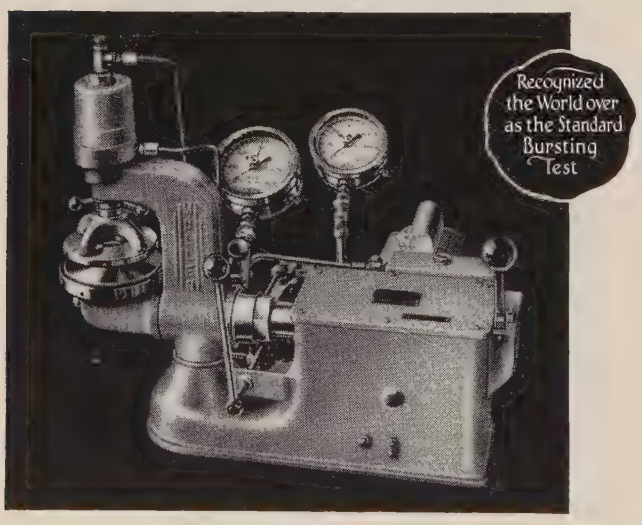
IRON & BRASS WORKS
PAPER MACHINERY SPECIALISTS • HUDSON FALLS, N. Y.
Associated with Canadian Vickers, Ltd., Montreal,
Builders of Sandy Hill Designed Machinery in Canada

Motor Driven Model A Tester
With Hydraulic Clamping Device



Especially designed for testing corrugated container board. Larger clamping area and reproducible clamping at any desired pressure eliminates crushing and slippage of the sample.

Write today for prices on these new testers, also the cost of converting your present Model A machines.

B. F. PERKINS & SON, INC.
Holyoke, Massachusetts

"B," against the joint body. The total pressure, or force, at "B" then offsets to a high percentage the total pressure, or force, at "A." Body steam inlet is located 90° from rod support lugs.

Since both of these forces stem from the same operating pressure within the joint, the ratio between them remains a fixed constant. No matter how the operating pressure may vary, the seal will not be affected, the power reduction will remain the same percentage.

The manufacturer claims a 60% reduction in joint horsepower load with the compensator. In actual service, however, every installation has shown even greater savings. The dollars and cents savings will vary of course with operating pressures and speeds.

Acme-Fisher

Addition of facilities for new steel construction has been announced by Acme-Fisher, rubber lining specialists of Louisville, Ky. This has been done to save the company's clients costly delays usually entailed when metalwork to be protectively covered must first be separately ordered from independent steel fabricators.

Materials Handling

The Yale & Towne Mfg. Co., Philadelphia 15, Pa., has issued a revised edition of its popular "The How Book of Cost-Cutting Materials Handling." The 28-page book was prepared with the help of V. S. Karabasz, associate professor of industrial management at the Wharton School, University of Pennsylvania.

Fischer & Porter

Fischer & Porter Co., 841 Jacksonville Rd., Hatboro, Pa., has issued a new catalog (53-11) describing its field-mounted pneumatic controller.

B. F. Perkins

Cecil A. Potter, president of the Machinery and Engineering Corp. of Westminster, Mass., has been appointed general manager of B. F. Perkins & Son, Inc., Holyoke, Mass. He was formerly chief engineer of B. F. Perkins & Son.

Pennsalt

The new $8 million electrolytic chlorine and caustic soda plant of the Pennsylvania Salt Mfg. Co. at Calvert City, Ky., is now in production. It is equipped with De Nora cells.

James G. Baldwin has been appointed district sales manager in charge of the Los Angeles, Calif., plant of the Pennsylvania Salt Mfg. Co. of Washington.

Hewitt-Robins

Hewitt-Robins, Inc., 666 Glenbrook Rd., Stamford, Conn., is now marketing a new knotting screen for wood pulp.

Westinghouse

George H. McBride has been appointed assistant manager of the Westinghouse Electric Corp.'s Switchgear Div.

C. P. Walker has been named manager of the General Industries Section of Westinghouse Apparatus Div. at East Pittsburgh. This section is charged with the responsibility of coordinating the development and sale of Westinghouse equipment with the needs of the paper, textile, rubber, and lumber industries.

Westinghouse, Box 2099, Pittsburgh 30, Pa., has issued a new booklet (B-5808) on "Packaged Drives."

Link-Belt Speeder

Link-Belt Speeder Corp., Cedar Rapids, Iowa, has issued a 16-page bulletin on "How to Cut Costs—Speed Pulpwood Handling."

Bauer Bros.

Bauer Bros. Co., 1715 Sheridan Ave., Springfield, Ohio, has issued a bulletin (P-10) which describes the No. 510 single revolving disk refiner.

Oliver United

Oliver United Filters has announced that Thomas C. Reeves has been transferred from New York City to Asheville, N. C., as a sales engineer.

Lukens Steel

Lukens Steel Co., Coatesville, Pa., has issued conversion tables and theoretical weights for clad steel plates for the benefit of designers, engineers, and other initiating specifications for clad steels.

Nopco

Nopco Chemical Co., Dept. PC, Harrison, N. J., has announced the production of three new polyamide-type resins, suitable for solvent and hot melt application as decorative, greaseproof, waterproof, heat-sealing, and water-vaporproof coatings. Each of these resins may be blended with rosin and rosin derivatives, phenolic and maleic resins, S. S. grades of cellulose nitrate, and small amounts of paraffin wax.

Plant Maintenance Show

The Plant Maintenance and Engineering Show will be held in the International Amphitheatre, Chicago, Ill., on Jan. 25–28, 1954. Advance registration cards may be obtained from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y. Exhibitor lists may be obtained from Banner & Greif 18 E. 41st St., New York 17, N. Y.

OBITUARIES

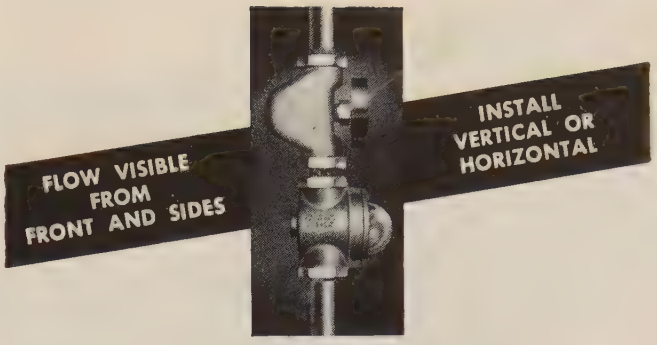
George Knox Spence

George Knox Spence, seventh President of the Technical Association of the Pulp and Paper Industry (1925–26) died of cancer on June 28. He is interred in Wardvale Cemetery, Johnsonburg, Pa.

George Knox Spence

Mr. Spence was born in New York, N. Y., on Dec. 10, 1872, the son of David and Anne Heslip Spence. He spent most of his youth in Pittsburgh, Pa., where his father was superintendent of the Carnegie Steel Co. He graduated in chemistry from Pennsylvania State College in 1895. In 1910 he received an M.S. degree from Penn State.

From 1895 until 1898 he was employed as chemist in a steel mill in Youngstown, Ohio. In January, 1898, he became chief chemist of the New York and Pennsylvania Co. (Castanea) with headquarters at Johnsonburg, Pa. He remained in this position until he retired in June, 1947, although he remained as a consultant to the company until his death.



A SIGHT-FLOW INDICATOR THAT NEVER CLOUDS OVER

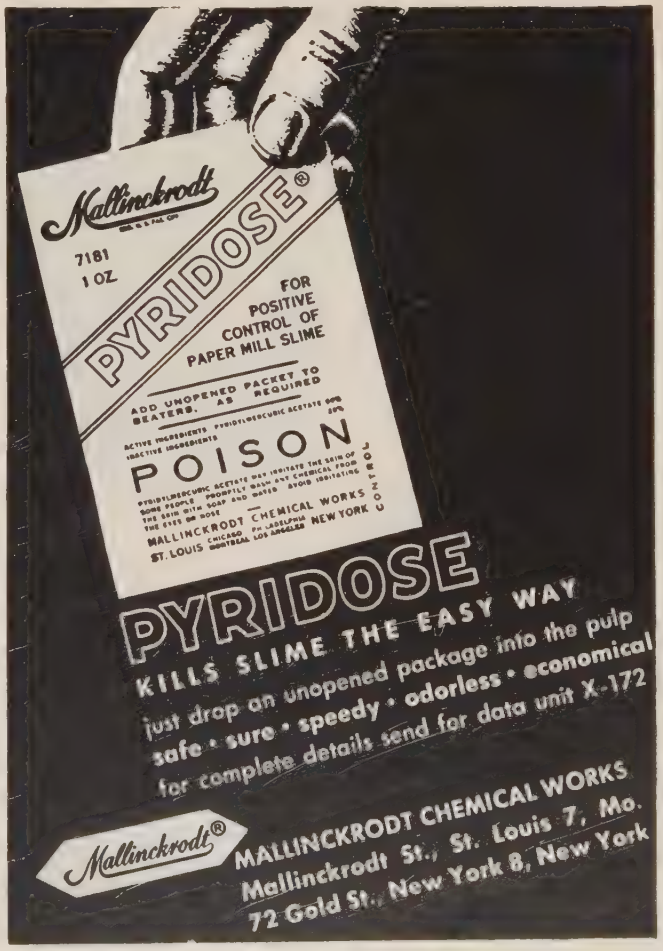
The Midwest Ball Sight-Flow is the one and only dryer condensate indicator with a "Window" that really stays clear—is constantly being scoured and kept clean by the violence of the liquid as it passes. The thousands already in use on both wet and dry end dryers prove that statement.

Equip your dryers, particularly the wet end section, and keep tab on condensate flow. Add Midwest non-corrosive temperature indicator to spot subnormal temperatures.

Sight-Flow fitting all bronze and non-corroding. Glass ball of heavy Pyrex glass and replaceable. Assembly effective for steam pressures up to 75#. Standard pipe sizes ½", ¾", 1", 1½". Temperature indicator also non-corroding.

Order several now and you'll order more later.

MIDWEST • FULTON MACHINE COMPANY
DAYTON, OHIO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ADD UNOPENED PACKET TO BEATERS. AS REQUIRED
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KILLS SLIME THE EASY WAY
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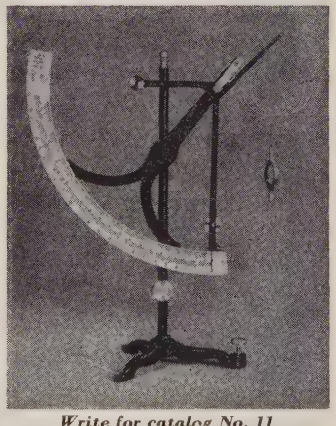
STANDARD DESK PAPER SCALES



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- tissues
- paper

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TESTING MACHINES, INC.

manufacturers and distributors of the finest test equipment for the paper, textiles, plastics, metals industries and laboratories.

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In Johnsonburg he served as a member of the town council for many years and two years as mayor.

In 1901 he was married to Anne Martin, who preceded him in death in 1942. He is survived by one daughter, Mrs. Henry Polk Vaughan (Margaret), of Clinton, Mich.; one son, Dr. George R. Spence, of Silver Spring, Md., and six grandchildren.

James Murray Kahn

James Murray Kahn, manager of the Pulp and Paper Div. of Infilco, Inc., died of a heart attack at Tucson, Ariz., on June 30, 1953.

Mr. Kahn was born in Chicago, Ill., on Sept. 26, 1902, and attended Armour Institute of Technology. He was associated with Infilco, Inc., for 31 years.

He is survived by his wife and three daughters.

Frank Fauquier Arnoldi

Frank Fauquier Arnoldi died in Toronto, Ont., on Aug. 6, 1953. Mr. Arnoldi was sales manager for the Boxboard Div. of Hinde & Dauch Paper Co. of Canada, Ltd., Toronto, Ont.

He was born in Toronto, Ont., on July 7, 1889, and graduated from the Royal Military College of Canada in 1911. Prior to World War I he was engaged as a civil engineer in railroad construction. During the war he advanced to the rank of Colonel and received the D.S.O. Bar honors.

Following the war he became production manager of Canadian Paperboard Co., Ltd. in Toronto, following which he became production manager and eventually sales manager for Hinde & Dauche Paper Co. of Canada, Ltd. He was active in the Board Committee of the CPPA Technical Section and was a regular attendant at TAPPI conventions. He became a member of the Technical Association of the Pulp and Paper Industry in 1930.

Edward T. A. Coughlin

Edward T. A. Coughlin, chief, Pulp and Paper Products Unit, Dept. of Defense, OQMG, Research & Development, Washington, D. C., died on Aug. 19, 1953, at his home in Richland, Mich. He had been operated on for appendicitis and appeared to be recovering but further kidney complications ensued.

Mr. Coughlin, a past-president of the American Pulp and Paper Mill Superintendents Association, was born in Holyoke, Mass., on April 6, 1891. In 1913 he graduated in chemical engineering from the University of Maine.

His past experience as a superintendent, manager, and research director included employment by The Allied Paper Mills, Kalamazoo, Mich., Franklin Coated Paper Co., Franklin, Ohio, New Jersey Coated Paper Co., Montclair, N. J., W. F. Hall Printing Co., Chicago, Ill., Pettingill, Inc., Chicago, Ill., Bryant Paper Co., Kalamazoo, Mich., and Chas. T. Main, Inc., Boston, Mass.

He became a member of the Technical Association of the Pulp and Paper Industry in 1916.

Robert I. Wynne-Roberts

Robert I. Wynne-Roberts, chief engineer of Finch, Pruyn & Co., Glens Falls, N. Y., died on Aug. 6, 1953.

Mr. Wynne-Roberts was born in Cape Town, S. A., on March 7, 1901, and graduated in chemical engineering from the University of Toronto in 1923.

His earlier employment was with the Sunbeam Lamp Works and Don Valley Paper Co. in Toronto and the International Paper Co., Bureau of Tests, in Glens Falls, N. Y. In 1940 he joined the Finch, Pruyn & Co. engineering staff.

Mr. Wynne-Roberts became a member of the Technical Association of the Pulp and Paper Industry in 1929 and, at one time, was chairman of its Mechanical Pulping Committee. He was married and had one child.

EMPLOYMENT SERVICE

Positions Open

P323-53. Quality Control Supervisor. To supervise installation of quality control program in midwestern corrugated box and folding carton plant. Prefer man experienced in both quality control and production.

P327-53. Graduate chemical engineer, preferably with pulping experience, wanted as manufacturer's representative to sell in Pennsylvania, New York, and New England.

Positions Wanted

E243-53. Production Superintendent. Well qualified in the manufacture of fine specialty grades. Yankee or fourdrinier machines. Capable of taking full charge of operation. Middle-aged. Married.

E244-53. Paper Technologist, experienced in development and sales. B.S. in chemical engineering. Over 20 years' practical application in research, quality control, development, converting, technical sales, and service. Excellent references. Desires position connected with technical development and sales.

E245-53. Technical Director. Ph.D., 38, broad background in polymers, plastics, paper converting. Publications and patents; registered patent agent. Knows waxing, coating, laminating, quality control, cost reduction, new product development, customer service. Present location metropolitan New York City.

E246-53. Paper Chemist, 28, B.S.Ch.E., Three years' experience in research, quality control, some production. Prefer mill position with small company in northwest.

E247-53. Technical Executive. B.S. Chemistry with graduate work. Married, two children. Desires position having a good future with a responsible corporation. Experience in research, development, management, and technical sales. Excellent references.

CELLULOSE CHEMIST

Large progressive organization offers excellent opportunity for cellulose chemist for fundamental research on interesting long-range program. Must have graduate training, preferably through the doctorate, and five or more years of research experience. Position is one carrying responsibility. Salary open. Location Midwest. Please send résumé of experience, education and personal data, including photo snapshot to TAPPI, P326-53, 122 East 44th St., New York 17, N. Y.

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Position requires an engineering degree and at least three years' experience in the pulp and paper industry. Age preferably not over 35 years. Salary commensurate with education and experience in chemical wood pulping and bleaching.

Give complete resume in first letter. Address letters to **TAPPI P325-53, Technical Association of the Pulp and Paper Industry, 155 E. 44th Street, New York 17, N. Y.**

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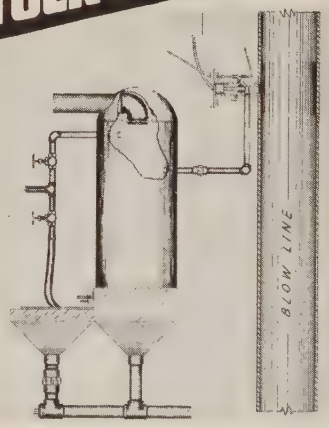
OBTAIN A SAMPLE OF PULP FROM VARIOUS LEVELS IN THE DIGESTER WITH MURCO-MOSINEE AUTOMATIC DIGESTER STOCK SAMPLER

1. Know when and where shives and poorly cooked pulp are being made . . . obtain a sample of pulp from various levels in the digester instead of one particular level.
2. Since you know at what level shives and poor pulp are forming, you can use corrective measures effectively on the next cook.
3. The timer is set so that any number of pulp samples can be taken automatically during the blowing of a digester, which furnishes a check on various levels as blown, since the time and level coordinate.
4. The timer can be set so that a large or small pulp sample can be secured from the digester.
5. No extra piping from the digester . . . attach it to the usual common blow pipe, as illustrated here. Stock sample, after it is blown into the receiver, can be automatically washed and cooled for laboratory analysis.



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MANUFACTURERS SINCE 1883
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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Officers of Local Sections

The local sections will start their new series of meetings this month. Meetings are held during the year from September to June. The annual meetings usually are held in May or June, at which time the officers for the next season are elected. The officers and executive committeemen who were elected for the 1953–54 terms are as follows:

Pacific

Chairman—F. J. Weleber, Publishers' Paper Co., Oregon City, Ore.
Vice-Chairman—E. H. Nunn, Crown Zellerbach Corp., West Linn, Ore.
Secretary-Treasurer—H. B. Petersen, Hercules Powder Co., Portland, Ore.
Executive Committee—Officers and B. T. Briggs, Rayonier, Inc., Shelton, Wash.; T. R. Probst, Columbia River Paper Mills, Portland, Ore.; J. M. Fulton, Pacific Coast Supply, Portland, Ore.; R. I. Thieme, Scott Paper Co., Anacortes, Wash.; E. H. Woodruff, Rayonier, Inc., Port Angeles, Wash.; and S. E. Hazelquist, Weyerhaeuser Timber Co., Longview, Wash.
Past-Chairmen—C. R. P. Cash, R. S. Wertheimer, C. W. Morden, R. B. Hansen, Lawrence Killam, M. W. Black, W. R. Barber, Carl Fahlstrom, G. H. McGregor, N. W. Coster, F. A. Olmsted, C. E. Braun, E. P. Wood, C. A. Enghouse, Erik Ekholm, H. W. Bialkowsky, G. H. Gallaway, J. L. McCarthy, H. C. Wall, W. F. Holzer, R. I. Thieme, E. O. Ericsson, and S. E. Hazelquist.
National Executive Committee Representative—W. F. Holzer, Crown Zellerbach Corp., San Francisco, Calif.

Lake States

Chairman—Robert J. Seidl, Forest Products Lab., Madison, Wis.
Vice-Chairman—L. A. Moss, Whiting-Plover Paper Co., Stevens Point, Wis.
Secretary—S. R. (Jim) Parsons, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
Treasurer—J. M. Bard, Marathon Corp., Menasha, Wis.
Executive Committee—Officers and G. H. Chidester, Forest Products Lab., Madison, Wis.; R. A. Diehm, Ward Paper Co., Merrill, Wis.; S. J. Baisch, Thilmany Pulp & Paper Co., Kaukauna, Wis.; and R. P. Whitney, Institute of Paper Chemistry, Appleton, Wis.
Past-Chairmen—G. K. Hill, Otto Kress, R. J. LeRoux, A. T. Gardner, S. D. Wells, J. R. Fanselow, H. W. Morgan, E. H. Voightman, R. A. Nugent, M. L. Downs, N. L. Malcove, J. H. Graff, T. R. Probst, J. P. Weidner, H. P. Dixson, L. V. Forman, C. J. West, Jr., A. M. Heald, G. R. Sears, H. C. Crandall, A. P. Adrian, and H. W. Rowe.
National Executive Committee Representative—H. F. Lewis, Institute of Paper Chemistry, Appleton, Wis.

Delaware Valley

Chairman—F. J. Lovegren, P. H. Glatfelter Co., Spring Grove, Pa.
First Vice-Chairman—E. R. Padavic, Container Corp. of America Manayunk, Pa.
Second Vice-Chairman—E. C. Molin, Glassine Paper Co., West Conshohocken, Pa.
Treasurer—Philip E. Nethercut, Scott Paper Co., Chester, Pa.
Secretary—Chas. R. Calkins, Riegel Paper Corp., Milford, N. J.
Executive Committee—Officers and J. P. Weidner, Container Corp. of America, Manayunk, Pa., and H. C. Brill, E. I. du Pont de Nemours & Co., Pigments Dept., Newport, Del.
Past-Chairmen—W. R. Maull, G. E. Landt, H. P. Cannon, H. C. Schwalbe, J. d'A. Clark, C. M. Connor, E. J. Albert, J. D. Davis, W. M. Shoemaker, A. L. M. Bixler, John Macadam, J. P. Weidner, A. S. Erspamer, and H. C. Brill.
National Executive Committee Representative—W. D. Harrison, Riegel Paper Corp., Milford, N. J.

Kalamazoo Valley

Chairman—R. H. Hurst, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Vice-Chairman—J. A. Dean, Michigan Paper Co., Plainwell, Mich.
Secretary—Richard T. Trelfa, Watervliet Paper Co., Watervliet, Mich.
Treasurer—Robert Elias, Western Michigan College, Kalamazoo, Mich.
Executive Committee—Officers and F. C. Goodwill, St. Regis Paper Co., Kalamazoo, Mich.; C. E. Mueller, Lockport Felt Co., Kalamazoo, Mich.; J. A. Wise, Kalamazoo Paper Co., Kalamazoo, Mich.; W. F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.; and Thomas Luey, Sutherland Paper Co., Kalamazoo, Mich.
Past-Chairmen—M. D. Bardeen, E. F. Whittington, H. C. Bradford, C. C. Scnieder, H. M. Annis, M. R. Wilkins, W. F. Hathaway, P. de Guehery, W. A. Kirkpatrick, F. L. Chappel, F. D. Elliot, F. R. Hamilton, E. B. Taylor, R. C. Germanson, R. T. Mashburn, H. L. Mimms, P. W. Bartholomew, S. L. Kukolich, J. J. Harrison, J. R. Dam, and A. T. Luey.
National Executive Committee Representative—W. F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.

New England

Chairman—F. S. Klein, Byron Weston Co., Dalton, Mass.
Vice-Chairman—Gordon Benson, St. Regis Paper Co., East Pepperell, Mass.
Treasurer—H. T. Barker, Bird & Son, Inc., East Walpole, Mass.
Secretary—R. W. Ramsdell, Hercules Powder Co., Holyoke, Mass.
Executive Committee—Officers and Miss Helen U. Kiely, 10 Monroe St., Northampton, Mass.; F. L. Simons, Crane & Co., Dalton, Mass.; P. L. Haggerty, Geo. LaMont & Son, Nutley, N. J.; J. T. Loomer, Robert Gair Co., Inc., Uncasville, Conn.; C. L. Reece, Whiting Paper Co., Holyoke, Mass.; C. I. Horton, 10 Hudson St., Norwalk, Conn.; Freeman Perry, Chemical Paper Mfg. Co., Holyoke, Mass.; and George Wallace III, Fitchburg Paper Co., Holyoke, Mass.
Past-Chairmen—F. C. Clark, R. C. Griffin, J. B. Calkin, R. H. Doughty, N. I. Bearse, W. L. Foote, L. B. Tucker, C. H. Child, P. S. Bolton, R. J. Proctor, and H. W. Knudson.
National Executive Committee Representative—Norman I. Bearse, Champion-International Co., Lawrence, Mass.

Ohio

Chairman—J. L. Clouse, Oxford Miami Paper Co., West Carrollton, Ohio.
Vice-Chairman—H. R. Joiner, Champion Paper and Fibre Co., Hamilton, Ohio.
Corresponding Secretary—John F. Nolan, Sorg Paper Co., Middletown, Ohio.
Recording Secretary—E. H. Shriver, The Mead Corp., Chillicothe, Ohio.
Treasurer—G. B. Gregg, Cincinnati Gas & Electric Co., Cincinnati, Ohio.
Executive Committee—Officers and C. E. Brandon, Howard Paper Mills, Dayton, Ohio; Lee Buechler, Crystal Tissue Co., Middletown, Ohio; D. J. Goodman, Sorg Paper Co., Middletown, Ohio; H. A. Smith, The Mead Corp., Chillicothe, Ohio; and Arthur Thurn, Champion Paper and Fibre Co., Hamilton, Ohio.
Past-Chairmen—V. F. Waters, H. H. Latimer, K. P. Geohegan, J. E. Burdsell, H. C. Fisher, C. D. Roess, S. I. Olsen, D. M. Yost, P. S. Cade, Arthur Thurn, D. J. Goodman, H. A. Smith, and C. E. Brandon.
National Executive Committee Representative—G. H. Pringle, The Mead Corp., Chillicothe, Ohio.

Empire State

Chairman—D. Chace Mather, Carthage Paper Makers, Carthage, N. Y.
Chairman-Elect—Fred G. Sommerville, Armstrong Cork Co., Fulton, N. Y.
Secretary-Treasurer—Ralph N. Prince, J. & J. Rogers Co., Au-Sable Forks, N. Y.
Executive Committee—Officers and H. D. Cook, Sweet Bros., Phoenix, N. Y.; J. W. Crocker, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.; I. V. Earle, Upson Co., Lockport, N. Y.; H. M. Gray, Oswego Falls Corp., Fulton, N. Y.; P. L. Hag-

ANACONDA METAL PRODUCTS

Copper, and copper alloyed with zinc, tin, nickel, lead, aluminum, phosphorous, manganese, silicon, selenium, cadmium and chromium in all combinations that can be wrought into sheets, strips, plates, wire, rods, bars, seamless tubes, drawn and extruded special shapes, and die pressed forgings.

Pulp and Paper Mill Applications

For years, Anaconda Copper and Copper Alloys have been used to solve corrosion and mechanical problems in pulp and paper mills; in many instances through the development of special alloys to provide combinations of qualities not obtainable in standard materials.

Among the Anaconda Products and Metals used extensively in the pulp and paper industries are:

WIRE

Brass shute wire and Phosphor Bronze warp wire for weaving into Fourdrinier screens and cut cloth for cylinder molds. Phosphor Bronze and Silicon Tin Bronze winding wire for cylinder mold construction.

RODS AND BARS

*Everdur, Phosphor Bronze, Naval Brass and other Copper Alloy rods for cylinder mold construction.

*Everdur screws, bolts, nuts, washers and tie rods for wood vat and tank construction, and for most pulp and paper mill fastening requirements.

Phosphor Bronze and special alloy Jordan and Beater Bars.

WELDING RODS

Copper and Copper Alloy welding rods for gas and arc welding.

SHEETS AND PLATES

*Everdur, Brass and Copper sheets and plates for welded and brazed construction of tanks, vats, "save-all" pans, and for lining cylinder vats, and head boxes.

*Reg. U.S. Pat. Off.

PIPE AND TUBES

Red Brass tubes, specially fabricated for Fourdrinier table rolls, felt rolls, guide rolls and other types of paper mill rolls.

Large-diameter, cold-drawn, Seamless Copper Tubes for stock and water lines up to 26″ I.D. in all standard and many special wall thicknesses.

Small-diameter, cold-drawn, Seamless Copper Tubes for lubricating and air lines and for meters.

Anaconda 85 Red Brass and Copper S.P.S. Pipe for use with threaded fittings.

Anaconda Copper Water Tubes are made in nominal diameters ¼″ to 12″. They are supplied hard drawn and soft annealed in 20-foot straight lengths; and soft in 100-foot coils up to 1″ diameter and 60-foot coils in 1¼″ and 1½″ diameters.

ELECTRICAL CONDUIT

*Everdur Electrical Conduit in Rigid (threaded) and EMT, is listed under Factory Inspection and Label Service Procedure by Underwriters' Laboratories, Inc. This non-rust, corrosion-resistant, high-fatigue-limit material is used in locations where excessive dampness or corrosive fumes are present. 53215

TECHNICAL SERVICE

Corrosion Resistance of copper and copper base alloys to specific corrodents is discussed and tabulated in Anaconda Publication B-36, "Corrosion Resistance of Copper and Copper Base Alloys." A free copy will be mailed upon request.

ANACONDA
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THE AMERICAN BRASS COMPANY

General Offices: Waterbury 20, Connecticut

F. J. Weleber, Publishers' Paper Co.; Chairman, Pacific Section

R. J. Seidl, Forest Products Laboratory; Chairman, Lake States Section

garty, George LaMonte Sons, Nutley, N. J.; R. W. Kumler, American Cyanamid Co., New York, N. Y.; G. S. Martin, F. C. Huyck & Sons, Renssalaer, N. Y.; J. D. Parmele, St. Regis Paper Co., Deferiet, N. Y.; R. A. Premo, Gould Paper Co., Lyons Falls, N. Y.; and W. R. Willets, Titanium Pigment Co., New York, N. Y.

Past-Chairmen—J. H. Schuber, C. E. Libby, J. H. Rich, R. F. Huntley, F. C. Goodwill, H. D. Cook, F. J. Lang, W. O. Hisey, F. J. McCourt, H. A. Spencer, John Campbell, M. L. Jaffe, J. E. Foote, C. E. Foster, H. J. Perry, J. S. Reichert, and R. M. Drummond.

National Executive Committee Representative—C. J. Sibler, Va. Pulp & Paper Co., New York, N. Y.

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Chairman—H. M. Gray, Oswego Falls Corp., Fulton, N. Y.
Chairman-Elect—F. W. O'Neil, New York State College of Forestry, Syracuse, N. Y.
Secretary—R. G. Hitchings, New York State College of Forestry, Syracuse, N. Y.
Treasurer—S. E. Church, New York State College of Forestry, Syracuse, N. Y.

EASTERN DISTRICT

Chairman—J. W. Crocker, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.
Chairman-Elect—G. G. Cole, Diamond Match Co., Plattsburg, N. Y.
Secretary-Treasurer—G. H. Hocking, Socony-Vacuum Oil Co., Albany, N. Y.

METROPOLITAN DISTRICT

Chairman—R. W. Kumler, American Cyanamid Co., New York, N. Y.
Chairman-Elect—J. C. Rice, Lowe Paper Co., Ridgefield, N. J.
Secretary-Treasurer—J. H. Doherty, Union Bag & Paper Corp., New York, N. Y.

NORTHERN DISTRICT

Chairman—J. D. Parmele, St. Regis Paper Co., Deferiet, N. Y.
Chairman-Elect—S. J. Young, National Paper Products Div., Crown Zellerbach, Carthage, N. Y.
Secretary—R. J. Murtaugh, St. Regis Paper Co., Deferiet, N. Y.
Treasurer—J. H. Treadwell, Treadwell Supply Co., Watertown, N. Y.

WESTERN DISTRICT

Chairman—G. K. Storin, Niagara Alkali Co., Niagara Falls, N. Y.
Chairman-Elect—J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.
Secretary—F. P. Heil, Lockport Felt Co., Lockport, N. Y.
Treasurer—E. F. Andrews, International Paper Co., Niagara Falls, N. Y.

Maine-New Hampshire

Chairman—Joseph J. Thomas, S. D. Warren Co., Cumberland Mills, Me.
Vice-Chairman—Arthur E. Jones, Oxford Paper Co., Rumford, Me.
Secretary-Treasurer—Harold E. Pratt, Pejepscot Paper Div., Brunswick, Me.
Executive Committee—Wadsworth L. Hinds, Keyes Fibre Co., Waterville, Me.; F. A. Strovink, American Cyanamid Co., Boston, Mass.; J. B. Calkin, New York, N. Y.; J. F. Wright, National Aniline Div., Boston, Mass.; Albert E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt.; F. N. Sprague, St. Regis Paper Co., Bucksport, Me.; Roland J. Martin, Fraser Paper Co., Madawaska, Me.; Henry S. Hooper, Penobscot Chemical Fiber Co., Great Works, Me.; and J. H. Heuer, Great Northern Paper Co., Millinocket, Me.
National Executive Committee Representative—George A. Day, Brown Co., Berlin, N. H.

Chicago

Chairman—Edward C. Berg, Ace Carton Co., Chicago, Ill.
Vice-Chairman—James D. Johnson, Container Corp. of America, Chicago, Ill.
Secretary—James R. Lyons, Atlas Boxmakers, Inc., Chicago, Ill.
Treasurer—J. J. McIntyre, H. B. Fuller Co., Chicago, Ill.
Executive Committee—Officers.
Past-Chairmen—H. R. Alley, H. E. Weston, F. D. Long, J. L. Kubicka, Warren R. Price, G. A. Zinkel, Albert K. Roach, and V. V. Vallandigham.
National Executive Committee Representative—W. F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.

Lake Erie

Chairman—R. L. Lewis, Ohio Boxboard Co., Rittman, Ohio.
Second Vice-Chairman—Eldon Cronquist, Inland Container Co., Ashtabula, Ohio.
Secretary—R. C. Matthews, Chase Bag Co., Chagrin Falls, Ohio.
Treasurer—M. A. Veigel, National Aluminate Corp., Cleveland, Ohio.
Financial Secretary—S. B. Gulliford, Gulliford Printing Co., Cleveland, Ohio.
Executive Committee—E. S. Furlong, Container Corp. of America, Cleveland, Ohio; L. K. Burnett, Ohio Boxboard Co., Rittman, Ohio; C. P. Spring, Chase Bag Co., Chagrin Falls, Ohio; J. F. Richmond, Ace Electrotype Co., Cleveland, Ohio; W. C. Hasselo, Container Corp. of America, Cleveland, Ohio; W. O. Manor, Consolidated Paper Co., Monroe, Mich.; and C. J. McDowell, Corn Products Co., Pittsburgh, Pa.
Past-Chairmen—L. K. Burnett and William Schoenberg.
National Executive Committee Representative—L. K. Burnett, Ohio Boxboard Co., Rittman, Ohio

Southeastern

Chairman—Malcolm Pineo, Brunswick Pulp and Paper Co., Brunswick, Ga.
Vice-Chairman—C. N. Rogers, Sonoco Products Co., Hartsville, S. C.
Secretary-Treasurer—George S. Scofield, Rayonier, Inc., Fernandina, Fla.
Executive Committee—Officers.
Past-Chairman—Glenn C. Kimble.
National Executive Committee Representative—J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

Papermakers and Associates of Southern California

Chairman—T. S. Markov, Fibreboard Products, Inc., Los Angeles, Calif.
Vice-Chairman—Lloyd J. Deen, Volney Felt Mills, Compton, Calif.
Secretary-Treasurer—R. W. Lewis, Container Corp. of America, Los Angeles, Calif.
Executive Committee—J. T. Cooey, Container Corp. of America, Los Angeles, Calif.; Otto Sass, Pioneer-Flintkote Co., Los Angeles, Calif.; and L. Long, Pioneer-Flintkote Co., Los Angeles, Calif.
Past-Chairmen—Herman L. Joachim, U. C. Farmer, C. G. Frampton, W. A. Kinney, F. H. Wheelock, R. S. Buckley, John Van Ounsem, W. G. Hartford, Bruce F. Brown, Jr., Robert W. Stevens, Claude Sharp, Wm. C. Birdsey, and J. T. Cooey.

Review of 1952–53 Section Meetings

The following review is a record of the meetings held by the TAPPI local sections during the past year. Local section meetings usually begin in September and end in June. With the exception of outings and business meetings no meetings are held in July and August. A report of the meetings held during 1951–52 was published in the September, 1952, issue of *Tappi*.

Pacific

The Pacific Section was organized at Seattle, Wash., in June, 1929. The annual meeting is usually held in May.

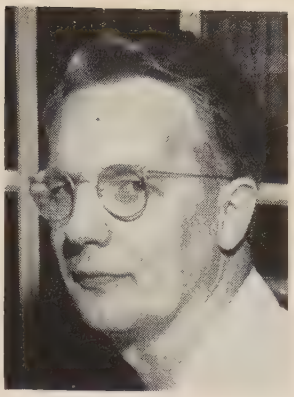
Sept. 18–19 and 22–23, 1952 (at Portland, Ore., and Seattle, Wash., respectively): Sixth Annual Seminar on "Recent Research on Cellulose and Lignin," by Karl Freudenberg, Research Institute for Chemistry of Wood and Polysaccharides, Univ. of Heidelberg, Heidelberg, Germany.

Nov. 18, 1952 (Camas, Wash.): Annual Engineering Meeting, Don Platt, Crown Zellerbach Corp., presiding. (1) "Two-Stage Feedwater Treatment at the Camas Steam Plant," by Morris Rivers, Steam Power Staff Engineer, Crown Zellerbach Corp., and Kenneth Linehan, Feed Water Analyst, Crown Zellerbach Corp. (2) "Development and Application of Fabricated Valves and Fittings for the Pulp and Paper Industry," by Harold Hilton, Northwest Copper Works, Portland, Ore. (3) "Problems of Exterior Maintenance of Pulp and Paper Mill Buildings," by Don Felthous, Weyerhaeuser Timber Co., Longview, Wash. (4) "The How and Why of Protective Coatings," by Raymond P. Hill, President, Chemical Proof Construction, Inc., Seattle, Wash. Dinner meeting at Crown Zellerbach Inn, Camas, Wash. Dinner speaker, E. Robert de Luccia, vice-president, Pacific Power & Light Co., Portland, Ore.

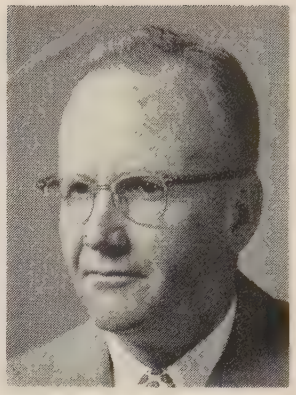
Jan. 13, 1953 (Seattle, Wash.): Panel discussion on "Routine Analytical Methods," E. Gray King, Puget Sound Pulp & Timber Co., moderator. (1) "Multistage Separation of Substances Between Two Immiscible Liquids," by V. F. Felicetta and Joseph L. McCarthy, Pulp Mills Research Dept. of Chemistry and Chemical Eng., Univ. of Wash., Seattle, Wash. (2) "Determination of Salt Cake Loss at the Brown Stock Washers," by Peter Taranoff, St. Helens Pulp & Paper Co., St. Helens, Ore. (3) "Iodate Test for SO_2 in Stack Gases," by Gordon K. Bonham, Anacortes Div. of Coos Bay Pulp Corp., Anacortes, Wash. (4) "Total Solids in Kraft Black Liquor," by Lloyd A. Nault, St. Regis Paper Co., Tacoma, Wash. (5) "The Determination of Red Liquor (Spent Sulphite Cooking Liquor) Solids by Permanganate Consumption," by Erwin H. Olson, Weyerhaeuser Timber Co., Longview, Wash. (6) "The Volumetric Determination of Beta and Gamma Cellulose," by Fred R. Foley, Puget Sound Pulp & Timber Co., Bellingham, Wash. (7) "A Method of Evaluating Dyes for Mill Use," by Edward T. Parker, Crown Zellerbach Corp., Camas, Wash. Dinner speaker, P. C. Cross, Executive Officer of the Dept. of Chemistry and Chemical Eng., Univ. of Wash.

March 13, 1953 (Longview, Wash.): Annual Shibley Award Meeting. Program Chairman, Joseph L. McCarthy, Dept. of Chemistry & Chemical Eng., Univ. of Wash. (1) "Fiber Flocculation," by D. E. Beasley, Crown Zellerbach Corp., West Linn, Ore. (2) "Pulp Mill Process Water from a Salt Contaminated River," by Andrew A. Broz, Weyerhaeuser Timber Co., Everett, Wash. (3) "Microbiological Control Studies Evaluation of a New Biocide," by R. J. Herschler, Crown Zellerbach Corp., Camas, Wash. (4) "Measurement of Dimensional Stability of Insulation Board," by S. Gordon Craig, Simpson Logging Co., Shelton, Wash. D. E. Beasley was presented with a check for $50 for his winning paper. All four contestants were presented Sutermeister textbooks.

May 21–23, 1953 (Gearhart, Ore.): Joint Annual Spring Meeting with Pacific Coast Div. of the American Pulp & Paper Mills Superintendents Association. (1) "Preparation of Chlorine Dioxide Bleaching-SO_2 Reduction of Sodium Chlorate," by J. B. Heitman, Pennsylvania Salt Manufacturing Co., Tacoma, Wash. (2) "Paper Machine Maintenance," by W. W. Clarke, Longview Fibre Co., Longview, Wash. (3) "Black Liquor Oxidation," and "Evaporator Tube Plugging," by Hugo Trygg, Weyerhaeuser Timber Co., Springfield, Ore. (4) "Housekeeping in a Sulphite Mill," by L. R. Wood, Rayonier, Inc., Hoquiam, Wash. (5) "Ammonia Versus Calcium Base Acid Making, Cooking and Screening," by Lauren LaFond, Crown Zellerbach Corp., Lebanon, Ore. (6) "Evaporating and Burning of Ammonia Base Waste Liquor," by James H. Hull, Crown Zellerbach Corp., Camas, Wash. (7) "Dirt Count and Evaluation," by H. V. Charnell, Rayonier, Inc., Port Angeles, Wash. (8) "Alhfors Screens, Centri·Cleaners and Vortraps in Kraft, Pulp and Paper," by L. W. Heard, Longview Fibre Co., Longview, Wash. (9) "Centri·Cleaners and Vortraps in an Unbleached Sulphite Mill," by Harlan Cladfelder, Spaulding Pulp & Paper Co., Newberg, Ore. (10) "Study of the Centri·Cleaner," by Fred R. Sievers, Crown Zellerbach Corp., Camas, Wash. (11) "Dirt Count Comparison with Oliver's Alhfors Versus Flat Screens," by M. C. Kaphingst and A. W. Strang, Columbia River Paper Mills, Vancouver, Wash. (12) "Lindblad Screens as Used for Screening Bleached Kraft Pulp," by Gerald W. Hough, Weyerhaeuser Timber Co., Longview, Wash.



F. J. Lovegren, P. H. Glatfelter Co.; Chairman, Delaware Valley Section



R. H. Hurst, Kalamazoo Vegetable Parchment Co.; Chairman, Kalamazoo Valley Section

Lake States

The Lake States Section was organized in Menasha, Wis., on Oct. 17, 1930. Meetings are usually held on the second Tuesday of each month at the Conway Hotel in Appleton, Wis., unless otherwise indicated. No meetings are held in December and February.

Sept. 10, 1952: "Lignin and Its Formation in Plant Tissue," illustrated with photomicrograph slides, by Karl Freudenberg, Director of Chemisches Institute, University of Heidelberg, Germany. World authority on the structure and chemistry of lignin, cellulose and tannins.

Nov. 11, 1952 (Institute of Paper Chemistry, Appleton, Wis.): Guided tour of the Institute. Panel discussion, "Papermaking Properties of Pulps"; moderator, D. J. MacLaurin, head of the Pulping and Paper Testing Groups at the Institute. (1) "The Drainage Properties of Pulp Slurries," by R. P. Whitney. (2) "The Equilibrium Moisture Content of Pulps," by W. A. Wink. (3) "Comment on the Optical Method for Determination of Bonded Area of Pulp Sheets," by J. A. Van den Akker. (4) "Gas Adsorption as a Technique for Measuring Fiber Surface," by W. R. Hazelton (Candidate for Ph.D.; preliminary report on thesis work). (5) "Some Relationships Between Refining Methods and Sheet Strengths," by D. J. MacLaurin. Except for Mr. Hazelton, all speakers were members of the Institute staff. After dinner at the Conway Hotel a talk on "Sell for America" was delivered by W. F. Luckenbach, Jr., manager of Industrial Sales Dept., Virginia Smelting Co.

Jan. 13, 1953: "Stainless Steel in the Pulp and Paper Industry," by F. A. Guba, Carpenter Steel Co., Tube Div., Union, N. J.

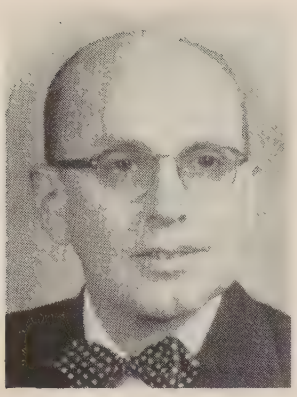
March 10, 1953 (Northland Hotel, Green Bay, Wis.): Panel discussion on "Save-Alls," Clyde Faulkender, technical director of Hoberg Paper Mills, Green Bay, Wis., moderator. (1) "Flotation Type Save-Alls," by Paul Easton, Sveen Pedersen Co. (2) "Mechanical Type Save-Alls," by Richard Ahrens, Improved Machinery Corp. (3) "Sedimentation Type Save-Alls," by F. O. Sullivan, Infilco, Inc.

April 15, 1953 (Nepco Nekoosa Mill, Nekoosa, Wis., and Elks Club, Wisconsin Rapids, Wis.): Guided tour of the Nekoosa mill. Panel discussion, "Wet End Operating Conditions and Paper Qualities"; moderator, B. L. Kassing, Nepco director of Process and Product Development. (1) "Rag Bonds," by L. A. Moss, Whiting-Plover Paper Co., Stevens Point, Wis. (2) "Glassine," by L. Parkinson, Rhinelander Paper Co., Rhinelander, Wis. (3) "Sulphite Papers," by L. Sabatke, Marathon Corp., Rothschild, Wis. (4) "Kraft Papers," by R. D. Rusch, Mosinee Paper Mills Co., Mosinee, Wis. (5) "Coating Papers," by W. J. Foote, Consolidated Water Power & Paper Co., Stevens Point, Wis. After dinner at the Elks Club: "Economic and Engineering Problems Involved in Building New Mills," by Harold Ingraham, Chas. T. Main, Inc., Boston, Mass.

May 19, 1953 (Butte des Morts Country Club, Appleton, Wis.): "Zaney Inventions Galore; Inspiration for Solving Pulp and Paper Problems," by the "Wacky Wizard of Waukesha," Waukesha, Wis. Election of officers.

Delaware Valley

The Delaware Valley Section was organized at Philadelphia, Pa., in June, 1931. Meetings are held monthly at the



J. L. Clouse, Miami Paper Co.; Chairman, Ohio Section

D. C. Mather, Carthage Paper Makers; Chairman, Empire State Section

Engineers Club, 1317 Spruce St., Philadelphia, Pa. The following meetings were held during the 1952–53 season:

Sept. 19, 1952: Afternoon mill visit to the Container Corp. of America, Manayunk, Pa. Dinner meeting at the Engineers Club followed by a panel discussion on the subject "Cylinder Machines." Moderator, G. T. Renegar, Container Corp. of America, Manayunk, Pa. Panel members: Thomas E. Brookover, Downingtown Paper Co., Downingtown, Pa.; Harold N. Holcombe, Schmidt & Ault Paper Co., York, Pa; and George M. Suydam, Riegel Paper Corp., Milford, N. J.

Oct. 23, 1952: "Measurement of Paper Properties Important in Offset Printing," by Gordon C. Wheeler, Lithograph Technical Foundation, Chicago, Ill.

Dec. 12, 1952: "Problems of Managing a Paper Mill" by H. H. Hanson, president, W. C. Hamilton & Sons., Miquon, Pa.

Jan. 22, 1953: Panel discussion on "Development of Paper Properties." Moderator, Ward D. Harrison, vice-president in charge of production, Riegel Paper Corp., Milford, N. J. Panel members: C. M. Connor, vice-president, W. C. Hamilton and Sons, Miquon, Pa.; Arthur J. Haug, paper mill superintendent, Scott Paper Co., Chester, Pa.; Elmer Mitchell, superintendent, McDowell Paper Mill, Glassine Paper Co., Manayunk, Pa.; William D. Rice, in charge of Chemical Engineering Development Div., Technical Dept., P. H. Glatfelter, Co., Spring Grove, Pa.; and John P. Weidner, Technical Superintendent, Container Corp. of America, Manayunk, Pa.

March 26, 1953: "Increased Production from Existing Machines," by John R. Curtis, Scott Paper Co., Chester, Pa.

April 23, 1953: Panel discussion on "Paper Defects." Panel members: L. P. Thompson, moderator, production manager, Paper Div., Personal Products Corp., Milltown, N. J.; H. H. Dana, manager, Paper Div., Curtis Publishing Co., Philadelphia, Pa.; Malcolm B. Lowe, Jr., superintendent, Lowe Paper Co., Ridgefield, N. J.; W. H. Moon, production manager, National Paper Co., Ransom, Pa.; H. T. Nicolson, superintendent, National Vulcanized Fibre Co., Yorklyn, Del.; E. R. Smith, mill manager, Union Mills Paper Manufacturing Co., New Hope, Pa.

May 28, 1953: Edward J. Albert, Award Program. "The Canadian Standard Freeness Test vs. a Drainage Time Test for Highly Refined Stock," by R. S. Becker, Riegel Paper Corp., Milford, N. J. (winning presentation); "A Nonstatistical Approach to Improving Wet Strength Resin Evaluation," by Vince Moser, Rohm and Haas Co., Philadelphia, Pa.; "Retention of Wet Strength Resins by Various Types of Pulp," by F. J. Newhard, Scott Paper Co., Chester, Pa. Judges: C. A. Shubert, Mead Corp., Chillicothe, Ohio; W. B. Morehouse, Nopco Chemical Co., Harrison, N. J.; and Donald Bradner, E. I. du Pont de Nemours & Co., Wilmington, Del.

Kalamazoo Valley

The Kalamazoo Valley Section was organized May 4, 1931, at Kalamazoo, Mich. Its meetings are usually held at the Harris Hotel in Kalamazoo, Mich., on the first Thursday of each month.

Oct. 2, 1952: "Management's View of the Technical Department." Speakers: George K. Ferguson, Watervliet Paper Co., Watervliet, Mich.; Maxwell Bardeen, Lee Paper Co., Vicksburg, Mich.; Fred Buchanan, National Gypsum Co., Kalamazoo, Mich.; Dwight L. Stocker and John Wood, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.

Nov. 6, 1952: "Notes on Paper Opacity," by William R. Willets, Titanium Pigment Corp., New York, N. Y.

Dec. 4, 1952: "Production Control in Papermaking and Printing," by W. R. Purcell, Brown Co., Berlin, N. H., and O. H. Somers, Western Printing and Lithographic Co., Racine, Wis.

Jan. 15, 1953: Annual Papermakers' Get-Together. Held jointly with the Michigan Div. of the American Pulp and Paper Mill Superintendents Association. Subject, "Some Economic Aspects of the Pulp and Paper Industry," by A. Newell Rumpf, Harris Bank and Trust Co.

Feb. 10, 1953: "Fiber Treatment for Strength Development," by James d'Arcy Clark, Longview Wash.

March 19, 1953: Graphic Arts Meeting. Held jointly with the Superintendents Association. "How to Make Better Packages," by Albert Kner, Container Corp. of America, Chicago, Ill.

April 2, 1953: Sizing Symposium. Afternoon and evening sessions. "Rosin Sizing," by Ralph Kumler, American Cyanamid Co., New York, N. Y. "Quilon as a Sizing Agent," by R. J. Pavlin, E. I. du Pont de Nemours Co., Wilmington, Del. "CMC Sizing," by Harris O. Ware, Hercules Powder Co., Wilmington, Del. "Evaluation and Significance of Rosin Sizing," by John B. Brainbridge, Monsanto Chemical Co., Everett, Mass.

May 7, 1953: Annual Senior Thesis Presentation. Pulp and paper students, Western Michigan College.

June 9, 1953 (Gull Lake Country Club, Kalamazoo, Mich.): Fun Day. Election of officers.

New England

The New England Section was organized at Holyoke, Mass., on Dec. 9, 1932. The following meetings were held during the current year:

Oct. 10, 1952 (Berkshire Inn, Great Barrington, Mass.): E. E. Dickey, Institute of Paper Chemistry, Appleton, Wis., discussed "Possible Uses of Atomic Radiation in the Paper Industry." "Demonstration of Instruments Used in Radiation Studies," by Tracer Lab., Inc., Cambridge, Mass. Also, L. F. Livingston of E. I. du Pont de Nemours & Co., Wilmington, Del., discussed "Progress and Better Living."

Nov. 21, 1952 (Hotel Roger Smith, Holyoke, Mass.): The entire meeting was known as "Helen Kiely Night" and was in the form of a testimonial to Miss Kiely who, for years, was director of Laboratories for American Writing Paper Corp., Holyoke, Mass., and has now given up most of her duties at this company.

March 20, 1953 (Hotel Roger Smith, Holyoke, Mass.): E. C. Harrington, manager of Industrial Statistics, Monsanto Chemical Co., Springfield, Mass., discussed "Increasing the Efficiency and Economy of Experimentation." This talk was supplemented by slides further illustrating his subject.

June 19–20, 1953 (Poland Spring House, Poland Spring, Me.): "Coating Groundwood Booksheets as Used in High Speed Letterpress Printing," by Paul Thoma and Frank Lincoln of Time, Inc. "Coated Papers and the Lithographic Process" by John D. Payne, S. D. Warren Co. "Some Things We Would Like to Know About the Printability of Boxboard," by Ward Verseput of Robert Gair Co., Inc. "The Printability of Paper for Gravure," by Fulton McArthur of W. W. Fitzhugh Co.

Ohio

The Ohio Section was organized on Nov. 30, 1934, at Middletown, Ohio. Meetings were held during the past year at the Manchester Hotel in Middletown unless indicated otherwise in the following list.

Sept. 15, 1952: Afternoon round table, "Research on Natural and Artificial Lignin and Its Constitution," and evening meeting, "The Formation of Lignin in Plant Tissues," by Karl Freudenberg, Heidelberg University Chemical Institute, Heidelberg, Germany.

Oct. 14, 1952: "The Measurement of Color," by J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.

Nov. 18, 1952 (American Legion Hall, Middletown, Ohio): "Power Distribution System for Paper Mills," by H. B. Thacker, Westinghouse Electric Corp., East Pittsburgh, Pa. Combined meeting with Miami Valley Superintendents Div.

Dec. 11, 1952 (Moose Auditorium, Hamilton, Ohio): "Stream Improvement," by M. C. Conner, W. C. Hamilton and Sons, Miquon, Pa., and followed by film, "River at Your Door" available from Middlesex Sewerage Authority, New Brunswick, N. J.

Jan. 8, 1953: "Polyethylene Extrusion Processes and Uses," by Robert Sturken, Frank W. Egan and Co., Bound Brook, N. J., and K. A. Arnold, St. Regis Paper Co., Deferiet, N. Y.

Feb. 10, 1953: "More and Better Research," by Francis J. Curtis, vice-president and director, Monsanto Chemical Co., St. Louis, Mo.

March 10, 1953: "Selection of Technical Personnel," by J. E. Todd, Institute of Paper Chemistry, Appleton, Wis.

April 9, 1953 (Springfield, Ohio): "Gravure Printing," by A. C. Black, Crowell-Collier Publishing Co., Springfield, Ohio. Evening meeting preceded by afternoon plant visits to Bauer Bros., Springfield, and Crowell-Collier. Additional tours of Crowell-Collier were made after the evening meeting in the company cafeteria.

May 14, 1953 (Hartwell Club House, Cincinnati Gas & Electric Co., Cincinnati, Ohio): Annual meeting and election of officers.

Empire State

The Empire State Section began holding meetings in 1935 and received its charter on April 2, 1938. In 1943, the Section was reorganized on a regional basis with meetings being held in four districts (Central, Eastern, Northern, and Western) of New York State. In 1948, the Metropolitan District was added.

June 8–10, 1953 (Whiteface Inn, Lake Placid, N. Y.): Annual meeting: "Air Removal from Paper Machine Stock," by G. Hughson, Canadian International Paper Co., Gatinean, Que.; "Semichemical Pulping of Hardwood," by H. L. Field, West Virginia Pulp & Paper Co., Mechanicville, N. Y.; "Some Causes and Means of Elimination of Static Electricity," by L. E. Walkup, Battelle Memorial Institute, Columbus, Ohio; "Masking Airborne Malodors—Utilization of Aromatic Chemicals in Industrial Odor Abatement," by B. K. Tremaine, E. I. du Pont de Nemours & Co., Wilmington, Del.; "Dirt Removal with the Centri-Cleaner," by E. L. Rastatter, Bauer Bros., Springfield, Ohio; and "Atomic Power," by E. C. Fuller, Champlain College, Plattsburg, N. Y.

May 1, 1953 (University Club, Syracuse, N. Y.): The third annual dinner for the Seniors at the College of Forestry, State University of New York, was held at the University Club in Syracuse, N. Y. R. G. Macdonald was the speaker.

CENTRAL DISTRICT (University Club, Syracuse, N. Y., first Friday of month)

Oct. 3, 1952: "Ultra Precision Coating of Traveling Webs," by J. W. Couture, Dilts Machine Works, Fulton, N. Y.

Nov. 7, 1952: "Evaluating the Quality of the Water of the Oswego River," by D. W. Geffken, Oswego Falls Corp., Fulton, N. Y.

Dec. 5, 1952: "Beating—An Old Angle," by H. D. Cook, Sweet Bros. Paper Mfg. Co., Inc., Phoenix, N. Y.

Jan. 9, 1953: "Control of Microbiological Growths in Pulp and Paper Mills," by Ernest Reed, Syracuse University, Syracuse, N. Y.

Feb. 6, 1953: "High Yield Pulping," by R. M. Husband, College of Forestry, State University of New York, Syracuse, N. Y.

March 6, 1953: "The Manufacture and the Requirements of Bread Wraps," by John Spalding, Marathon Corp., Oswego, N. Y.

April 3, 1953: "Fibers and Polarized Light," by F. G. Sommerville, Armstrong Cork Co., Fulton, N. Y.

May 1, 1953: Senior Dinner—"Personal Development Through Local Section Activity," by R. G. Macdonald, TAPPI, New York, N. Y.

June 5, 1953: Ladies' Night.

EASTERN DISTRICT (Milfranks Restaurant, Lake George Rd., Glens Falls, N. Y., third Thursday of month)

Oct. 16, 1952: Panel discussion on "Consistency Control and Measurement," by E. J. Trimbey, Trimbey Machine Works, Glens Falls, N. Y.; Ray De Zurik, De Zurik Shower Co., Sartell, Minn.; A. J. Sloan, Pandia, Inc., New York, N. Y.; and Arthur Landesman, Fischer & Porter Co., Hatboro, Pa.

Nov. 20, 1953: "Corrosion in Action," by H. O. Teeple, International Nickel Co., New York, N. Y.

Dec. 18, 1952: "Maintenance Control," by Sam Rarig, Marinette Paper Co., Ft. Edward, N. Y.

Jan. 15, 1953: "Atomic Energy," by Dr. Edward Fuller, Champlain College, Plattsburg, N. Y.

Feb. 12, 1953: Panel discussion on "Routine Control Methods," by representatives from Imperial Paper Co., West Virginia Pulp & Paper Co., International Paper Co., and Marinette Paper Co.

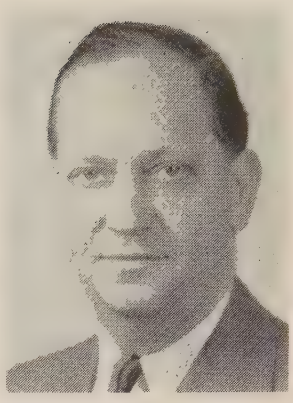
March 19, 1953: "The Future of Northeastern Paper Mills," by Gordan Shattuck, Strathmore Paper Co., West Springfield, Mass.

April 16, 1953: Junior paper presentations.

May 23, 1953: Ladies' Night.

METROPOLITAN DISTRICT (Fraunce's Tavern, New York, N. Y., second Tuesday of month)

H. M. Gray, Oswego Falls Corp.; Chairman, Central District, Empire State Section



J. W. Crocker, Sandy Hill Iron & Brass Works; Chairman, Eastern District, Empire State Section

Oct. 14, 1952: Panel discussion on "Development of Specialty Papers to Capture New Markets," by G. C. Borden, Riegel Paper Corp., Milford, N. J.; W. T. Cusack, Aldine Paper Co., New York, N. Y.; and L. S. Tobias, International Paper Co., New York, N. Y.

Nov. 12, 1952: Panel discussion on "Rubber Latices for Paper," by R. L. Steller, B. F. Goodrich Chemical Co.; E. J. Heiser, Dow Chemical Co.; and J. S. Hickman, E. I. du Pont de Nemours.

Dec. 9, 1952: "Progress in Cellulose Chemistry and Its Industrial Applications," by Herman F. Mark, Polytechnic Institute of Brooklyn.

Jan. 13, 1953: "Paper Board and Its Manufacture," by Edward Manogue, Gibralter Corrugated Paper Co., North Bergen, N. J., and J. T. Loomer, Robert Gair Co., Uncasville, Conn.

March 10, 1953: "Printing Papers," by F. B. Lincoln, Jr., Time, Inc., Springdale, Conn., and C. V. Morris, Henry Lindenmeyer & Sons, New York, N. Y.

April 14, 1953: Panel discussion on "Consumer-Unit Packaging," by C. M. Woodcock, General Foods Corp., New York, N. Y.; P. K. Wolper, Riegel Paper Corp., Milford, N. J.; and W. L. Hardy, Foster D. Snell, Inc., New York, N. Y.

May 12, 1953: Ladies' Night.

NORTHERN DISTRICT (Hotel Woodruff, Watertown, N. Y., second Thursday of month)

Oct. 9, 1952: "Our Natural Resources," by J. S. Illick, New York State College of Forestry, Syracuse, N. Y.

Nov. 13, 1952: "The Legislature Aspects of Forests in New York State," by Senator Paul Graves and Assemblymen Benjamin Demo and O. S. Wilcox, New York State Legislature, Albany, N. Y.

Dec. 11, 1952: "The Utilization of Hardwoods," by John McGovern, Forest Products Lab., Madison, Wis.

Jan. 15, 1953: "What Holds Paper Together?," by W. Galley, E. B. Eddy Co., Hull, Que.

March 12, 1953: "Sell for America," by W. F. Luckenback, Jr., Virginia Smelting Co., West Norfolk, Va.

April 9, 1953: "Recent Developments in Paper Machine Drives," by S. E. Franklin, Westinghouse Electric Corp., Pittsburgh, Pa.

May 14, 1953: Ladies' Night.

WESTERN DISTRICT (Niagara Falls, N. Y., first Wednesday of month)

Oct. 1, 1952: "Wood Fiber as Used for Insulation," by F. D. Forsyth, Wood Conversion Co., St. Paul, Minn.

Nov. 5, 1952: "Stream Pollution," by H. A. Rothchild, Kimberly-Clark Corp., Neenah, Wis.

Dec. 3, 1952: Plant visitation, Moore Business Forms, Inc.

Feb. 4, 1953: "Power Generation and Its Distribution," by C. S. Taft, International Paper Co., Niagara Falls, N. Y.

March 17, 1953: "This Chemical Age," by D. Walkington, Canadian Industries, Ltd. Co., St. Catherines, Ont.

April 16, 1953: Ladies' Night.

Maine-New Hampshire

The Maine-New Hampshire Section was organized at Orono, Me., on Oct. 25, 1950, and received its charter at Bangor, Me., on Oct. 26, 1945.

Nov. 7–8, 1952 (Lafayette Hotel, Portland, Ore.): In accordance with established procedure, the Maine-New Hampshire

R. W. Kumler, American Cyanamid Co.; Chairman, Metropolitan District, Empire State Section

J. J. Thomas, S. D. Warren Co.; Chairman, Maine-New Hampshire Section

Section held two meetings during the past business year, each consisting of a week-end symposium. The Fall meeting was held in Portland, Me., and dealt with Topic No. 9—*Pulping.* The following papers were presented: "Bleaching Pulp with Chlorite," by Ralph Carr, manager of Technical Service, Mathieson Chemical Corp., Baltimore, Md.; "Values of Acidic Reducing Agents in Kraft Bleaching," by H. B. Channon, Technical Service Dept., Virginia Smelting Co., W. Norfolk, Va.; "High Density Hydrogen Peroxide Systems," by R. L. McEwen, Research and Development Dept., Buffalo Electro-Chemical Co., Inc., Buffalo, N. Y.; and "Modern Washing and Bleaching at S. D. Warren Co.," by Robert Nivison, sales manager of the Improved Paper Machinery Corp., Nashua, N. H.

An outstanding feature of this meeting was a plant tour through the new Brown Stock and Bleaching Plant of the S. D. Warren Co., which was made on Saturday morning; preceding this trip was a talk by one of the Warren technical staff, briefly outlining the flow diagrams of the plant and its features.

June 19–20, 1953 (Poland Spring, Me.): The Spring meeting was held in conjunction with the New England Section at Poland Spring and the topic was "Methods of Testing to Predict Printability by Gravure, Letterpress and Offset." "Some Things We Would Like to Know About the Printability of Boxboard" by H. W. Verseput of the Robert Gair Co., Inc., New York, N. Y.; "Printability of Paper for Gravure," by Fulton McArthur of the W. W. Fitzhugh Co., Brooklyn, N. Y.; "Coated Papers and the Lithographic Process," by John D. Payne of the S. D. Warren Co.; and "Coated Groundwood Book Sheets as Used in High Speed Letterpress Printing," by Paul Thoma and Frank Lincoln of Time, Inc., Springdale, Conn. Following the usual custom Saturday morning was devoted to a panel discussion on the topic of the "Printability of Paper and How to Measure It." Also presented were two movies by the Harris-Seybold Co. on "Offset Lithography."

Chicago

The Chicago Section was organized as the Chicago Professional Paper Group in Chicago, Ill., in October, 1943. In 1946 the group became the Chicago Section. All meetings are held in the rooms of the Chicago Bar Association on the third Monday of each month.

Sept. 18, 1952: "Paper at Work," by H. Runyan, field secretary of the Graphic Arts Association of Illinois, Chicago, Ill.

Oct. 20, 1952: "The Paper Industry—Past, Present and Future," by A. Newell Rumpf, vice-president, Harris Trust & Savings Bank, Chicago, Ill.

Nov. 17, 1952: "Paper and Board Sizings and the Qualities They Inpart," by A. C. Dreshfield, consultant, Chicago Testing Lab., Chicago, Ill.

Jan. 19, 1953: "Palletizing in the Paper Industry," by Ray Frase, Addison-Semms Co., Racine, Wis.

Feb. 16, 1953: "Adhesives": Earl Lenz, Paisley Products Co., Chicago, Ill., "New Trends and Developments in the Adhesive Field"; R. E. Smith, H. B. Fuller Co., St. Paul, Minn., "Why Resin Adhesives Are So Popular"; Geo. Leighminger, Stein-Hall, Chicago, Ill., "Vegetable Adhesives"; and M. Snover, Williamson Adhesives, Skokie, Ill., "Latices and What You May Expect from Them".

March 16, 1953: "Laminators," by Frank W. Egan, F. W. Egan Co., Bound Brook, N. J.

April 20, 1953: "Quality Control from a Buyer's Viewpoint," by E. H. Balkema, General Purchasing Agent, Colgate-Palmolive-Peet Co., Jersey City, N. J.

May 18, 1953: "Packaging Specifications for High Speed Automatic Machinery," by Doug Wallace, Procter & Gamble, Cincinnati, Ohio.

Lake Erie

The Lake Erie Papermakers and Converters Association was organized at the Hickory Grille, Cleveland, Ohio, on Oct. 7, 1949. Meetings are held on the third Friday of each month at the Carter Hotel, Cleveland, Ohio. This organization received its charter as the Lake Erie Section on May 18, 1951.

Aug. 22, 1952: Summer Outing—guided tour through American Greetings Corp., Outing at Ridgewood Country Club, Cleveland, Ohio.

Sept. 19, 1952: "They're Always Judging Me," by Elroy R. Stromberg, chairman, Dept. of Psychology, Western Reserve University, Cleveland, Ohio.

Oct. 17, 1952: "What Printing Process for What Job," by Richard F. Knoppe, art director, packaging, Procter and Gamble Co., and Charles F. King, Technical Director, U. S. Printing and Lithograph Co., Cincinnati, Ohio.

Nov. 21, 1952: "The Battle of the Films," by J. M. Cowan, managing director of National Flexible Packaging Association, Chicago, Ill.

Dec. 12, 1952: Christmas Party, Hotel Carter.

Jan. 16, 1953: "Cost Saving Equipment for Today and Tomorrow." by Albert Shields, chief engineer, S & S Corrugated Paper Machinery Co., Brooklyn, N. Y., and D. E. Luscombe, engineer, Miehle Printing Press & Mfg. Co., Chicago, Ill.

Feb. 20, 1953: "Surface and Body Characteristics of Board for Printing," by A. T. Luey, staff technician, Sutherland Paper Co., Kalamazoo, Mich.

March 20, 1953: "Development of a Maintenance Program for Armco Steel," by J. B. Whitlock, general maintenance engineer, Armco Steel Corp., Middletown, Ohio.

April 17, 1953: "Printing Plates for Today's Product Demand," by Ralph H. Schwarz, president and general manager, Ace Electrotype Co., Cleveland, Ohio.

May 21–22, 1953: Two-day "Measurement and Control Conference" sponsored by the Section in cooperation with Engineering Div. of TAPPI, Instrument Society of America, Cleveland Section, and American Society for Quality Control, Cleveland Section. Theme: "Measurement and Control of Paper and Paperboard Manufacture and Conversion—Present and Future." Moderator, L. A. Moore, assistant chief engineer, The Black-Clawson Co., Hamilton, Ohio. Morning session: "Some Practical Application of Measurement and Control Instruments in a Paper Mill," by R. W. Peters, Assistant Superintendent, Paper Mill Div., Eastman Kodak Co., Rochester, N. Y.; "What the Papermaker and Converter Would Like to See Measured and Controlled," by Wm. H. Aiken, technical director, Gardner Board and Carton Co., Middletown, Ohio; "Instrumentation from Management's Viewpoint," by Sherman C. Lloyd, Electrochemicals Div., E. I. du Pont Co., Niagara Falls, N. Y. Afternoon session: "The Instrument Manufacturer's Problems in Meeting the Demands of the Papermaking and Converting Industries," by Henry Ehrisman, assistant general sales mfg., Foxboro Co., Foxboro, Mass.; "Process Controls Presently in Use in Other Industries Which Might be Applied to the Manufacture and Conversion of Paper and Paperboard," by John Green, steel industry sales mgr., Minneapolis-Honeywell Co. Philadelphia, Pa.; "Other Industry Experience in Measurement and Control Which May Be of Benefit to the Paper Industry," by Irving Lefkowitz, Case School of Applied Science, Cleveland, Ohio; "Measurement and Control of Paper Quality," by John F. Langmaid, Jr., assistant to production mgr., S. D. Warren Co., Cumberland Mills, Me. Evening session: "The Greatest Measurement and Control Problem of All—The Human Being," by H. A. Black, Industrial Relations Dept., the Mead Corp., Chillicothe, Ohio. Plant tours: Republic Steel Co. Strip Mill and Standard Oil Co. Refinery.

Southeastern

The Southeastern Section was organized as the Southeastern Pulp and Paper Society in 1951. In September, 1952, the Society became the Southeastern Section. The meetings are held in several cities of the Southeast, Jacksonville, Fla., Macon, Ga., Savannah, Ga., Brunswick, Ga., and Charleston, S. C.

Sept. 19 and 20, 1952 (St. Simons Island, Ga.): The Charter

M. B. Pineo, Brunswick Pulp & Paper Co.; Chairman, Southeastern Section

of the Southeastern Section was presented to the Society by R. G. Macdonald who spoke on "The Technical Man and the Pulp and Paper Industry." The technical papers were as follows: "The Present and Future Status of Research in the Pulp and Paper Industry," R. S. Hatch, director of research, Hudson Pulp and Paper Co.; "The Place of the Technical Man in the Pulp and Paper Industry," by G. W. E. Nicholson, vice-president, Union Bag & Paper Co. A tour of the Brunswick Pulp and Paper Mill was made on Saturday, Sept. 20, 1952.

Nov. 21, 1952 (Jacksonville, Fla.): "The Development of Chemi-Groundwood," by C. E. Libby, North Carolina State College, Raleigh, N. C.; "Job Organization and Construction Coordination," by K. G. Taylor, J. E. Sirrine Co., Greenville, S. C.; "Effect of Sulphidity on Bleached Sulphate Pulp Strength," by M. B. Pineo, Brunswick Pulp and Paper Co., Brunswick, Ga.; a preview of the tour of Rayonier, Inc., mill at Fernandina by F. B. Doherty, Rayonier, Inc. The tour of the mill was made the following morning.

Jan. 23–24, 1953 (Charleston, S. C.): "Instrumentation of Recovery Furnaces," by James Upson and T. C. Johnson, Union Bag & Paper Corp., Savannah, Ga., "Behavior of Southern Kraft Pulp at Negative Freeness," by R. C. Sproull, The Herty Foundation; "Principles of Beta-Ray Gage Control of Basis Weight," by J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis. On Saturday morning a panel discussion on "Evaluation of Unbleached Kraft Pulps," moderator, L. V. Forman, Scott Paper Co., Chester, Pa.

March 20–21, 1953 (Macon, Ga.): "Bleaching with Chlorine Dioxide," W. D. Harrison, Riegel Paper Corp., Milford, N. J.; "Neutral Sulphite Semichemical Spent Liquor Recovery," G. H. Chidester, U. S. Forest Products Lab., Madison, Wis. The program for the following day consisted of a tour of the Macon Kraft Co. mill and the plant of the Armstrong Cork Co.

May 8–9, 1953 (Savannah, Ga.): "Interpretation of Cooking Charts from Direct Steamed Kraft Digesters," by John Morris, Union Bag & Paper Corp., Savannah, Ga.; "Rapid Determination of Black Liquor Solids," by P. B. Borlew and S. J. Lancaster, Container Corp. of America, Fernandina, Fla.; "Semichemical Pulping, South Georgia-Florida," by T. W. Small, Sprout, Waldron and Co., Muncy, Pa.; "Georgia Forests and the Pulp and Paper Industry," by E. L. Demmon, Southeast Forest Experiment Station, Asheville, N. C. A tour of the Union Bag & Paper Corp. mill was made on the following morning.

Papermakers and Associates of Southern California

The Papermakers and Associates of Southern California was organized at Los Angeles, Calif., on May 15, 1941. All meetings are held at Ivan's Restaurant in Los Angeles on the third Thursdays of alternate months.

July 17, 1952: Maintenance panel: "Converting Machinery," Sherwood Wieman, Fibreboard Products, Inc.; "Power Plant Maintenance," Henry Hill, Pioneer-Flintkote Co.; and "Paper Machinery and Drives," Al Hatch and Les White, Container Corp. of America.

Sept. 18, 1952: "Printability of Board." Panel discussion. Panel members: Otto Sass, Pioneer-Flintkote Co.; William Richards, Container Corp. of America; Arron Miller, Kelco Co.; and Herb Brigden, Fibreboard Products, Inc.

Jan. 15, 1953: "Industrial Instrumentation," by Nels E. Swanson, Swanson Engineering & Mfg. Co., Los Angeles, Calif.

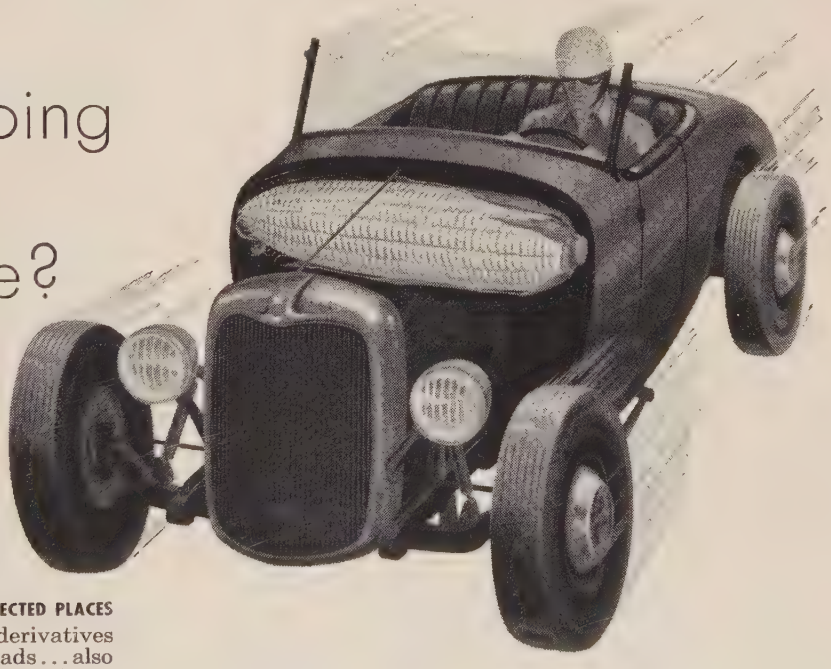
March 19, 1953: "Responsibilities of the Purchasing Department," by Al Smith, Fibreboard Products, Inc., and Al Lama, Los Angeles Brewing Co.

April 25, 1953 (Pasadena Athletic Club, Pasadena, Calif.): Annual Wino-Dino.

May 21, 1953: "Modern Trends in the Coloring of Boxboard and Tissue," by Robert M. True and T. B. Smock, General Dyestuff Corp., San Francisco, Calif.

July 16, 1953: Maintenance panel—panel members: Robert Stevens, consulting engineer; Ernst Tonjes, Pioneer-Flintkote Co.; and Al Hatch, Container Corp. of America.

what's **corn** doing hitting "70" down the pike?



CORN PERFORMS VITAL FUNCTIONS... IN MANY UNEXPECTED PLACES

Under the hood of your car for instance... derivatives of corn were used in casting the cylinder heads... also in extracting (from its oxide, alumina) the aluminum used in the pistons and other essential parts. This is but one of the numerous examples of how continuous basic research in corn helps American industry... helps you.

CORN PRODUCTS IN PAPER MANUFACTURE

For the paper industry Corn Products Refining Company supplies a variety of specialized starches and adhesives... superior formula ingredients for such processes as beating, corrugating and laminating.

We offer quality in volume supply unexcelled in the field. Complete technical service is available without cost or obligation. If you have a production problem why not check with Corn Products. We welcome your specific technical inquiries.

Manufacturers of

GLOBE® brand starch

AMIJEL® brand starch

CORAGUM® brand starch

LAM-O-DEX® brand gums

CORN PRODUCTS REFINING COMPANY, 17 Battery Place, New York 4, N. Y.

Hardness of Rubber-Covered Rolls (Plastometer Test)*

TAPPI Suggested Method T 640 sm-53

(THIS SUGGESTED METHOD IS UNDER THE JURISDICTION OF THE ENGINEERING RESEARCH AND MACHINE DESIGN COMMITTEE)

This method is intended to provide a dependable and reproducible procedure for determining the hardness of roll coverings made of rubber or similar compounds.

APPARATUS

The instrument, known as the Pusey and Jones Plastometer (*see* Figs. 1 and 2) determines the hardness by measuring the depth of an indentation made in the rubber surface by a steel ball, or indentor, 0.1250 ± 0.0005 inch in diameter, under the constant load of a weight of 1000 ± 0.1 grams for a period of 60 seconds. It consists essentially of a swivel-foot-supported frame in which are mounted parts essential to raise or lower the indentor and weight independently. The indentor is attached by a vertical shaft to the spindle of an indicator gage graduated in hundredths of a millimeter. A spirit level is mounted on the frame of the instrument to verify the perpendicularity.

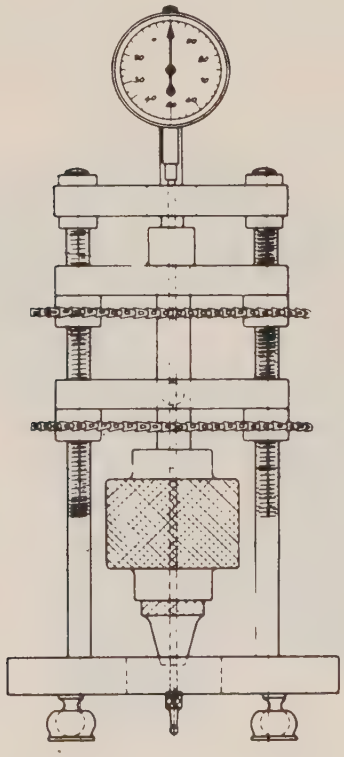


Fig. 1

PROCEDURE

Set the instrument firmly on the curved surface of the rubber-covered roll so that the center line of the indentor shaft is vertical and also perpendicular to the tangent at the point of contact of the indentor, as verified by centering the bubble in the spirit level mounted on the plastometer frame. Lower the indentor until contact is made with the specimen and continue lowering until the dial hand has made three complete clockwise revolutions, and has been brought to a stop on zero. Then carefully lower the weight onto the indentor, without shock, to the full extent of its travel. After the lapse of 60 seconds, during which period there will be plastic flow adjacent to the indentor, read the indentation value.

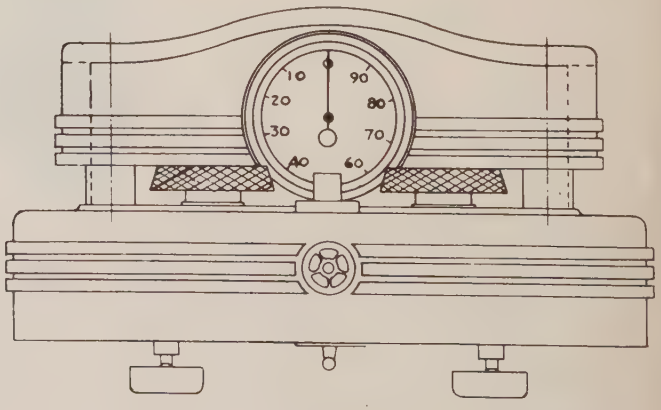


Fig. 2

Take three readings at different positions on the specimen, at the middle of the roll and 6 inches from each end. For comparative tests, the reading shall be

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taken at the same temperature, preferably 70 ± 2°F. Subject the test roll to this temperature until equilibrium is indicated by constant readings of the plastometer taken at intervals of 2 hours.

REPORT

The average of at least three readings made as above specified shall be reported as the indentation number. If the temperature is other than 70 ± 2°F. it shall be included in the report.

TOLERANCE

The following tolerances, plus or minus, shall be permitted when duplicate tests are made on the same roll at the same temperature by different operators or different instruments:

Indentation No.	*Tolerance*
Below 120	1
120 to 200	3
Over 200	8

Note: The hardness of rubber compounds commonly used for roll coverings varies inversely as the temperature. However, in the range between 65 and 80°F., the variation in hardness due to temperature changes will be slight and will be within the tolerances noted.

ADDITIONAL INFORMATION

ASTM Method 531 covers the procedure for determining the indentation of molded rubber samples $^1/_2$ inch thick, $1^1/_4$ inches wide, and 3 inches long by means of the Pusey and Jones Plastometer.

Fiber Length and Coarseness of Pulp by Projection*

TAPPI Suggested Method T 232 sm-53

(THIS SUGGESTED METHOD IS UNDER THE JUDRISDICTION OF THE PULP TESTING COMMITTEE)

This is a projection method by which the lengths of fibers in a pulp may be rapidly and quite accurately recorded. It may be used to determine the average fiber length of a sample, or if the sample is taken from a compartment of a fiber classifier so that the individual fiber lengths do not differ greatly (or if with an unbeaten pulp only the whole fibers are considered), the approximate weighted average fiber length may be calculated. This is obtained from the average fiber length and the ratio of the length of the few longest to the length of the few shortest fibers in the sample (*1*).

If l is the length of a fiber in a pulp sample, and w is its weight, and N fibers are measured; and if L is the sum of their lengths (i.e., Σl); then the average length is: $\Sigma l/N$, or L/N and the weighted average length is: $[\Sigma(lw)]/\Sigma w$.

With a few additional precautions and gravimetric measurements, the coarseness of the pulp specimen may be determined at the same time. Coarseness is defined as the weight per unit length of fiber, and is expressed as milligrams per 100 meters. This is 11.1 times the common "denier" used for textiles, which is defined as the weight in grams of 9000 meters of filament.

Unless only whole tracheids are considered, the numerical average fiber length is a trivial property and depends on the lower limit of particle length arbitrarily adopted. The weighted average fiber length is a fundamental property of pulps and relates directly to paper properties (*1*). If the sample has a wide range of fiber lengths, the weighted average fiber length can be determined accurately after fractionation as described in TAPPI Method T 233 sm.

The coarseness of the fibers is a measurement which has several advantages over that of the average width, since it includes the effects also of fiber thickness, the extent of the central canal (or lumen), and the density of the cellulosic material. The coarseness decreases with beating, as the fibers are split, and may be used to measure the splitting effect of beating or refining equipment.

APPARATUS AND MATERIALS

1. *Projector.* A vertical photographic enlarger or suitable 16-mm. or 35-mm. film slide projector, which has, or is modified to have, a space of about $^1/_2$ inch between the lamp housing and the stage to accommodate the cell; which can be mounted vertically; and whose lens system can be adapted to give a 4 by 4-inch image of a 5 by 5-mm. area on a stage within a distance of about 30 inches. (*See* Fig. 1.)

Note: Certain 35-mm. film slide projectors have enough clearance for this purpose without machining the housing, after the slide holder is removed. The required magnification may be obtained by adding one or two common circular magnifying reading lenses of about 1 to $1^1/_2$ inches in diameter, or better, a 1-inch diameter anastigmatic linen-counter lens. These may be obtained at most stationery or optical stores. The lens combination may be mounted at the top of the focusing tube, just below the stage, by wedging it in position. However, in testing the coarseness of beaten pulp, where fine fibrils are to be examined, it is better to use or equip a projector with an optically corrected lens system.

2. *Cell.* A container as shown in Fig. 2, comprising a metal, glass, or plastic tube about 5 or 6 cm. in diameter and 5 to 8 mm. long, mounted on a piece of flawless glass.

Note: A suitable cell may be made from a 5-mm. section of a plastic tumbler, stuck to a square of photographic plate with soft deKhotinsky cement.

3. *Image Grid.* A sheet of hard white paper, or preferably a sheet of white plastic with a mat finish, ruled with permanent black lines into a 4-inch square divided into 16 1-inch squares. (*See* Fig. 3.)

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4. *Magnification Scale.* A short piece of transparent plastic millimeter scale or a piece of a microscope slide with two parallel lines scratched exactly 5.0 mm. apart.

5. *Clinical Centrifuge (for Coarseness Measurements) with 15 or 20-ml. Tubes.* The tubes should be rinsed with a water-repellent solution, such as a benzene solution of aluminum stearate or a silicone, then dried to prevent their interiors from being wetted with water and to facilitate the transfer of fiber suspensions.

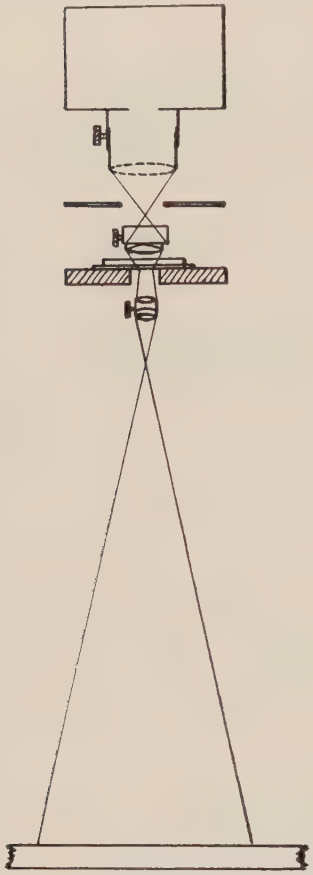

Fig. 1. Diagram of projection apparatus

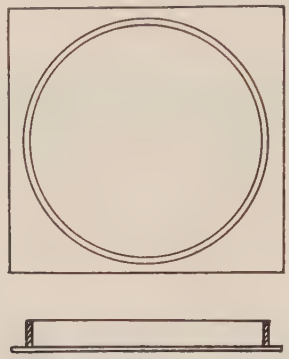

Fig. 2. Plan and elevation of cell for specimen

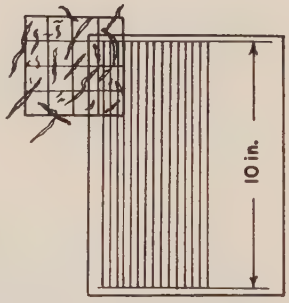

Fig. 3. Ruled paper over screen

6. *Recording Paper.* Sheets of translucent manifold paper $8^1/_2$ by 11 inches, with two parallel penciled lines at top and bottom exactly 10 inches apart and ruled into a grid with light penciled lines about 10 inches long and $^3/_8$ inch apart. (*See* Fig. 3.)

7. *Immobilizing Solution.* A 0.5% aqueous solution of locust bean gum is preferred. Place 1 gram of dry gum in a 250-ml. beaker and add about 5 ml. of water; stir well, and dilute to about 200 ml. Heat to 80°C. while continuing to stir. Allow to cool and let stand overnight to permit any suspended material to settle. Decant the clear liquid into a bottle and add a few drops of formaldehyde as a preservative. Common starch may be used in place of the gum if the latter is not available, but the solution is not as clear.

TEST SPECIMEN

For determination of fiber length, a representative sample of about 10 mg. or more is required. This is diluted to 100 ml. or more (0.1 gram per liter) in a beaker.

For determination of coarseness, 100 ml. or more of a representative suspension containing 0.04 ± 0.001 gram per liter of the pulp is required.

The presence of debris interferes with the coarseness measurement. If the percentage of debris passing through a 150-mesh screen in a classifier is known, it can be allowed for. However, it is better to mix together all the fractions remaining on the screens and prepare the specimen for coarseness from the composite mixture.

If a classifier is not available, wash a 0.5-gram representative sample of the pulp on a 200-mesh screen with a stream of water until the filtrate becomes clear. Drain the sample, place it in a 500-ml. stoppered cylinder, dilute to 250 ml., and shake well. Pour out approximately 200 ml. of this into a beaker, noting the volume poured out. Filter off the fibers in the beaker on a Gooch or small Büchner funnel and dry to constant weight. From this weight and the volume calculate the moisture-free weight of the pulp remaining in the cylinder and add sufficient water to reduce the consistency to 0.04 ± 0.001 gram per liter.

Pour about 150 ml. of this sample back and forth between two 250-ml. beakers several times to secure good mixing and immediately thereafter quickly pour an aliquot of about 10 ml. into one of the graduated centrifuge tubes. Read this volume accurately and record it.

Centrifuge the suspension for 5 minutes, decant the supernatant water, and rinse all the fibers from the tube into the cell so that they are suspended in about 4 ml. of water.

Pour an estimated 1 or 2 ml. of the locust bean gum solution into the cell, stir with a dissecting needle, and swirl and shake until the liquids are well mixed and the fibers evenly distributed.

Notes: (1) The locust bean gum serves not only to disperse the fibers, but also to immobilize them so that they do not move while being measured. This technique not only dispenses with the need for drying the suspension to fix the fibers, but prevents a certain amount of curling and twisting and contact of adjacent fibers during drying. There is, however, some danger that all the fibers will not lie horizontal, so that they will appear to be shorter than they are. This error can be more or less avoided by shaking the cell sideways rapidly back and forth. This will shake the fibers into near parallelism with the bottom of the cell and will also tend to disperse any fiber clots present.

(2) If the material forming the side of the cell is not water repellent, the inside surface should be painted with a benzene solution of aluminum stearate or a silicone, otherwise a meniscus will form so that the center of the cell will be almost denuded of fibers.

PROCEDURE

Calibrate the equipment as follows: Place an empty cell or a piece of glass of the same thickness as the bottom of the cell on the stage of the projector and lay the 0.5-cm. scale upon it. Adjust the distance of the projector above the table on which the image grid is laid, and the focusing, until the sharp images of the two scale lines exactly coincide with the sides of the 4-inch image grid and then paste or tape the screen to the table top in the center of the field.

Place the cell with the specimens on the stage of the projector, focus carefully, and examine different fields to be sure that the concentration of the fibers is fairly uniform in each. Otherwise, shake and tap the cell until this is satisfactory.

Without looking at the screen, move it so that a field near its back edge is projected. Place a sheet of the ruled manifold paper on the screen and, starting at the upper left hand 1-inch ruled square on the screen (*see* Fig. 3), move the paper so that the tip of a fiber which starts or ends in this 1-inch square coincides with the point at the top left-hand corner of the paper where the penciled lines intersect. Orient the paper so that the image of the fiber coincides as nearly as possible with the lightly drawn 10-inch line. If the fiber curves away from the line, rest the point of a sharp hard pencil where the curvature starts and, using the pencil point as a pivot, rotate the paper until more of the fiber coincides with the line; then move the pencil to where the image of the fiber curves off again. In this way, no matter how curled, the image of any fiber may be accurately straightened out.

Mark the end of the straightened fiber on the light line with a short heavy stroke of the pencil and proceed to record the length of the next fiber, starting at the intersection just marked. Do this in turn for every fiber which has an end lying in the upper left square and which has more than half its length within the 4-inch square (the latter only if the coarseness is also being measured). Proceed to the second top left-hand square and record the lengths of all the fibers having an end there and which do not originate in the first square examined. In the same way, proceed with the rest of the 16 squares in the screen, recording the lengths of all the fibers which have more than half of their lengths inside the 4-inch square screen and which are not shorter than 0.1 mm. (corresponding to an image length of about 2 mm.).

When the bottom of the light 10-inch line is reached on a fiber image, note the place by making a light pencil mark on the screen (the mat surface is provided for this purpose), then move the paper so that the top of the second line coincides with this mark, and continue. (It is well to mark the bottom of a line with a penciled circle if a fiber should happen to end there. The mark on the screen should be erased as soon as it has served its purpose.)

When all the fibers lying more than halfway in the screen have been examined, without looking at the screen move the cell along systematically into a new position and again record the length of all the fibers whose greater part lies within the 4-inch square screen.

While marking the lengths of each fiber, it is well to count them mentally, and note the number counted on the paper at the end of the last fiber examined in each 4-inch square field. In this way, record the lengths of about 200 fibers, which, if of average length, will be found in ten or fewer fields.

Note: When measuring coarseness, care should be exercised to examine the fields in the cell in such a way that a representative pattern is observed. In particular, the screen must not be observed when changing a field, in order to avoid bias, since one tends instinctively to avoid over and under-populated fields.

Measure the total length of the fibers recorded by counting the number of 10-inch lines filled, and adding the length of the record on the partially filled final line. Divide the total length in inches by the magnification factor (0.8 with the specified conditions) and by the number of fibers examined to obtain the numerical average fiber length.

CALCULATIONS

To obtain the weighted average fiber length (by weight), the ratio of the length of the longest normal fibers to the length of the shortest normal fibers (of those examined) is required. Because of the presence in almost every portion of fibers of a few stray fibers which are abnormally long or short, examine (from the record) the individual lengths of about 7.5% of both the longest and the shortest fibers (15 fibers each when a total of about 200 fibers have been measured); ignore the lengths of the five longest and the five shortest fibers; then find the average length b of the next ten longest and the average length a of the next ten shortest fibers. Divide b by a and increase this quotient, b/a, by 10%, to obtain the required ratio r.

The weighted average fiber length (by weight) then will be the numerical average length multiplied by $[4(l + r + r^2)]/[3(l + r)^2]$.

Note: An explanation of these steps will be found in an article by Clark (*1*). Depending on the magnitude of the ratio r (the ratio of the longest few to the shortest few fibers) for fairly uniform fibers such as those from a compartment of a fiber classifier, the weighted average length will be about 8 to 12% greater than the numerical average length, depending on the kind of classifier used.

To calculate the coarseness, the area of the cell must be known.

Let C = coarseness, mg. per 100 meters
A = area of cell, sq. cm.
N = number of fields examined
L = total length of fibers in N fields, mm.
V = volume of 0.04 g./l. suspension added to the centrifuge tube

Then,

$$C = \frac{1000V}{100{,}000} \times 4 \times \frac{(0.5)\,(0.5N)}{A} \times \frac{100{,}000}{L} = \frac{1000NV}{AL}$$

Notes: (1) If the debris is not washed from the specimen and it is found with a classifier that the quantity present is d%, then, because the fibers shorter than 0.2 mm. are not included in the count, and assuming that these have the same coarseness as the remainder of the specimen, decrease the calculated coarseness by d%.

(2) For the coarseness measurement, it is best to prepare two or three specimen cells, recording the lengths of about 100 fibers in each, so as to average out the variables in preparing the cell.

REPORT

Report the weighted average fiber length to the nearest 0.05 mm.

Report the coarseness in milligrams per 100 meters to two significant figures.

Report the average fiber length to the nearest 0.05 mm. and state the minimum fiber length included in the average.

ADDITIONAL INFORMATION

The term, weighted average fiber length, is defined as the average fiber length by weight as differentiated from the average fiber length by length, which would be obtained by dividing the total length of fibers present by the number of fibers. Weighted average length is in effect obtained by dividing the sum of the products of the length and weight of each fiber present by the combined weight of the fibers.

LITERATURE CITED

1. Clark, James d'A., "The Measurement and Influence of Fiber Length," *Paper Trade J.* 115, No. 26: 36–42 (Dec. 24, 1942); *Tech. Assoc. Papers* 15: 556–562 (1942).

Blood Resistance of Butchers' Wrapping Paper*

TAPPI Suggested Method T 486 sm-53

(THIS SUGGESTED METHOD IS UNDER THE JURISDICTION OF THE PAPER TESTING COMMITTEE)

Blood resistance of butchers' wrapping paper is defined for the purpose of this method as being the time of transudation, in hours, of blood from fresh hog liver through a sheet of paper to the extent that 25% of the area exposed to the liver has become discolored. This test is used to evaluate types of paper, such as butchers' wrapping paper, locker paper, etc., that are used for the packaging or wrapping of freshly cut meats. The degree of blood resistance is an important characteristic in papers used for this purpose.

MATERIALS AND APPARATUS

1. *Liver.* Pieces of mature hog liver, grade U. S. Good, approximately 2 square inches in area and not less than $^1/_4$ inch thick. It shall be fresh liver, stored for not less than one nor more than two days at approximately 40°F.
2. *Glass Shelf.* A piece of ordinary window glass of convenient size.
3. *Petri Dishes.* Diameter 4 inches.

TEST SPECIMEN

At least five specimens, each consisting of a single sheet of the paper approximately 2 inches square, are required. The test specimens shall be taken from different rolls or packages selected according to TAPPI Standard T 400 m.

PROCEDURE

The test shall be conducted on conditioned specimens and in an atmosphere conditioned in accordance with T 402 m.

Place at least five specimens on a sheet of glass with the felt side (or the printed or outer side) down. Then place one piece of freshly cut liver on each paper specimen, covering it with an inverted Petri dish to retard drying out of the liver. The Petri dish should not touch the liver.

Record the time elapsed, in hours, between the application of the liver and the appearance of the first stain or spot of blood penetration through the sheet. Also record the time in hours, required for 25% of the area exposed to the liver to become discolored.

REPORT

Results shall be reported to the nearest hour as initial blood transudation and as 25% blood transudation. The report shall include the number of specimens tested, and if desirable, results shall be reported separately for specimens tested with the felt, printed, or outer side up. The report shall give the average of all tests made and the maximum and minimum results, for the initial and 25% transudations, respectively.

* This method is suggested by the Standards Committee as being the most suitable to date. It is *not*, however, a TAPPI Standard. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

Pinholes in Glassine and Greaseproof Papers*

TAPPI Tentative Standard T 485 m-53

(THIS STANDARD IS UNDER THE JURISDICTION OF THE PAPER TESTING COMMITTEE)

This method covers procedures for the numerical estimation of pinholes per unit area in glassine, greaseproof, or other light-weight grease-resistant papers with two types of penetrants: (a) turpentine and (b) a slurry of carbon black and kerosene.

Pinholes in paper are defined for the purpose of this method as individual holes or openings large enough to permit the transudation of the penetrant in 60 seconds or less. The number, size, and distribution of pinholes are of significance in operations where the protection of foods, metals, chemicals, and other products against air and light is important.

APPARATUS

1. *Backing Paper.* Sheets of No. 2 coated book paper, 70 pounds, 25 × 38—500 basis, of convenient size.
2. *Brush.* No. 6 stencil brush, round, with conventional ink pot; or any equivalent stiff-bristled brush.
3. *Timer.* Stopwatch or electric timer, reading in seconds.

REAGENTS

A. *Turpentine.* Colored, water-free turpentine, prepared as follows: To each 100 ml. of turpentine oil, National Formulary, add 5 grams of anhydrous calcium chloride and 1.0 gram of a suitable oil-soluble red dye (Color Index No. 258). Stopper the container, shake well, and let stand for at least 6 hours, shaking

* This method has been approved as a tentative standard by the Standards Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

occasionally. Then filter through a dry filter paper at a temperature of approximately 70°F. and store in an air-tight bottle.

B. *Carbon Black-Kerosene Slurry.* To 20 grams of carbon black add 250 ml. of kerosene, using a ball mill if possible. Puddle the slurry until free of lumps or dry particles. Agitate the slurry just prior to applying to the paper.

Note: Other nonaqueous penetrants may be used for special purposes. In such cases, the penetrant shall be adequately described in the report.

TEST SPECIMEN

Sample the paper as specified in TAPPI Standard T 400 m, taking at least six specimens, each having an area of 72 square inches available for test. It is not essential to condition the paper at the standard temperature and humidity, but care should be taken to avoid folds, creases, punctures, or other obvious defects that would permit transudation of the penetrant.

PROCEDURE

Apply the penetrant (A or B) to the side of the paper which is to receive a coating or laminant or will be in contact with the material to be packaged. If this is not known, make an equal number of tests on each side. With a pencil, mark off an area of 72 square inches on the side of each test specimen on which the penetrant will be applied.

Place each specimen with the marked side uppermost and resting on a sheet of the book paper on a smooth, plain surface. With the stencil brush, apply a coating of the penetrant as quickly and as uniformly as possible over the designated test area. Start the timer as soon as the application is complete. Allow the coated specimen to remain in contact with the book paper for 60 seconds, then completely remove it and examine the exposed area of the book paper for spots stained by the penetrant.

REPORT

Report the average number of pinholes per square foot of specimen. Report also the number of specimens tested, the maximum and minimum number of pinholes, the penetrant used, and, if known, the side of the paper tested.

Fiber Length of Pulp by Classification*

TAPPI Suggested Method T 233 sm-53

(THIS SUGGESTED METHOD IS UNDER THE JURISDICTION OF THE PULP TESTING COMMITTEE)

This method is designed to measure the weighted average fiber length of a pulp. If a fiber is l mm. in length and weighs w micrograms, then for a given pulp, the weighted average length (L) is $\Sigma wl \div \Sigma w$, or the sum of the products of the weight times the length of each fiber divided by the total weight of the fibers in the sample.

The weighted average length is a fundamental property of pulp and there have been indications (*1*) that, provided the diameter of the fibers does not decrease with their decreasing length (there usually is some decrease, however, depending on the type and degree of treatment), the tensile strength of a sheet made from the pulp (other factors being the same) will vary as $L^{1/2}$, the burst will vary as L, and the tear as $L^{3/2}$. This will be true independently of the uniformity of lengths of the fibers; whether they are a mixture of various lengths or all of one length. The density of the sheet will not be affected by L if the fibers are the same thickness. The numerical average fiber length, on the contrary, is of much less significance, since if the fibers are of mixed lengths, it is an arbitrary measurement, largely influenced by the lower limit adopted below which a particle is no longer regarded as a fiber. The weighted average fiber length of a pulp may exceed the numerical average length by three or four times if particles down to a length of 0.01 mm. are included.

Ideally, it would be desirable to classify a pulp sample into a very large number of fractions and weight and measure the length of each in order to determine the weighted average length. In practice, however, satisfactory results may be obtained from the weights and lengths of five graduated fractions which are provided by a four-screen classifier.

APPARATUS

1. *Fiber Classifier.* Any good classifier with four or more screens is suitable. It is desirable to select the series of screens used for a given sample so that not much more than one fourth of the sample is held on the coarsest screen. It is also desirable to provide for the closer separation of the longer-fibered fractions than the short ones, since the weight effect of the long fibers is the greatest, and the weighted average fiber length of a given fraction can be determined more accurately if the lengths of the fibers in the fraction are uniform.

Suitable screen series are 14, 28, 48, and 100-mesh for medium-fibered pulps; 12, 20, 28, and 48-mesh for long-fibered pulps; and 20, 28, 48, and 100-mesh for short-fibered pulps. As a guide to the selection of the screens, a good classifier will retain on a given screen most of the fibers having a length of over twice the mesh opening.

2. *Hot Plate, Steam-Heated Cylinder, or Temperature-Regulated Drying Oven.* For drying the pads.

3. *Balance.* Sensitive to 0.01 gram.

4. *Projector.* For the measurement of fiber lengths. This is described in TAPPI Method T 231 sm.

5. *Disintegrator.* For preparation of dry samples. The disintegrator is described in TAPPI Standard T 205 m.

6. *Other Apparatus.* A Büchner funnel 60 or 80 mm. in diameter, filter paper, a suitable suction flask,

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graduated cylinders of 1 or 2-liter capacity, a mixing bucket, and a flat round dipper or mug for stirring the pulp in the bucket and measuring it out.

TEST SPECIMEN

If the pulp sample is dry, a representative sample of at least 24 grams is required. Soak it in water for at least 3 hours and disintegrate for 75,000 revolutions (20 minutes) in the disintegrator. If the pulp sample is in slush form, the disintegration is not required.

PROCEDURE

According to the maker's instructions for operating the classifier, measure out the approximate quantity of pulp required, plus at least half as much more for a consistency determination. Dilute the specimen in the mixing bucket to not over 0.5% consistency. Mix the suspension thoroughly and measure out into a graduated cylinder the equivalent quantity (a ml.) needed to make a classification test; then immediately measure out into another cylinder a quantity equal to one half or more of the pulp to be classified (b ml.).

Note: For greatest accuracy, it is best not to attempt the measurement of exact volumes of stock mixtures, particularly if the fibers are long. The entire content of each dipper should be added to the cylinder to bring the level up to about the volume wanted and then the exact volume read and recorded without attempting to make any adjustment.

An accuracy sample can also be prepared by forming a sheet in a sheet mold with an amount of pulp equal to twice that required for a classification test. This sheet is pressed in a standard way. The sheet is then quartered and alternate quarters weighed together on a beam balance. One portion (of two quarters) is then used for the classification and the other dried for determination of sample weight. In cases where the sample size is small and the loss of fines is important, a silk cloth should be used to cover the screen in the sheet mold to eliminate possible loss of fines.

Adjust the flow of water to the classifier and add the measured specimen a. Filter the other portion b through a filter paper on the Büchner funnel. Remove the pad, press to remove excess water (hand pressure between blotters is sufficient), and dry to constant weight, using the hot plate, heated cylinder or drying oven as desired.

When classification is complete (different cycles are recommended for the different instruments), if the average length of the fraction in a compartment is not known, then, as described in TAPPI Method T 232 sm, extract a specimen from each compartment. Determine the average fiber length of a composite sample of the fibers passing the last screen.

Note: For ordinary work, the average length may be assumed to be 0.2 mm. if the last screen is 48-mesh, and 0.1 mm. if it is 100-mesh.

Drain each compartment into its filter head and wash the screens and compartments carefully. Remove the pads, press to remove excess water, mark for identification, and dry to constant weight, as in the case of the pad from portion b.

When the pads are dry, weigh quickly on the balance.

CALCULATIONS

If w is the moisture-free weight in grams of the pad from portion b ml. of suspension, and W is the moisture-free weight of pulp added to the classifier; then

$$W = \frac{aw}{b}$$

If w_1, w_2, w_3, and w_4 are the moisture-free weights of the pads from the four compartments, respectively, and w_5 is the moisture-free weight of the pulp lost through the finest screen; then

$$w_5 = W - (w_1 + w_2 + w_3 + w_4)$$

If l_1, l_2, l_3, l_4, and l_5 are the average lengths in millimeters of the fibers in each fraction, and L is the weighted average fiber length of the pulp sample, then

$$L = \frac{w_1l_1 + w_2l_2 + w_3l_3 + w_4l_4 + w_5l_5}{W}$$

REPORT

Report the weighted average fiber length of the specimen in millimeters to the nearest 0.05 mm.

If desired, the percentages by weight of the fibers retained on each of the screens used may also be reported. In this case, record also the make of classifier used, weight of samples, time of processing, flow of water, and any other pertinent details.

ADDITIONAL INFORMATION

1. With experience, for a particular kind of pulp, the average lengths of fibers retained in a given compartment (with a given screen) will be known for a particular classifier operated under set conditions, and need not be redetermined. Under controlled operating conditions (with the exception of the first compartment), the average fiber length of the fraction retained in the intermediate compartments will remain remarkably constant. In the first compartment the average fiber length will depend on the species of wood and history of the sample.

2. Beating or refining will not substantially change the percentages retained in the intermediate compartments; the main effect is to decrease the percentage on the first screen and to increase the percentage through the finest screen by a similar amount.

3. Experience has shown that the fraction on any one screen of a classifier should not exceed 40% of the total weight of the sample. In the event this occurs, screen sizes should be readjusted to reduce the fraction retained on an individual screen.

4. In general, the sample size should conform to the manufacturer's specifications; however, it has been found that if the sample size is too great, it causes important differences. In all classifiers, matting of fibers on the screen must be avoided, as this results in a change in effective screen size. Sample size may be reduced to eliminate this effect.

LITERATURE CITED

1. Clark, James d'A., "The Measurement and Influence of Fiber Length," *Paper Trade J.* 115, No. 26: 36–42 (Dec. 24, 1942); *Tech. Assoc. Papers* 15: 556–562 (1942).

REFERENCES

1. Jones, G. D. O., Alexander, C., Ross, T. W., and Johnston, H. Wyatt, "A Proposed Standard Instrument for Classifying Papermaking Fibers According to Length," *Paper Trade J.* 96, No. 17: 29–36 (April 27, 1933).
2. Brainerd, Forrest W., "A New Fiber Classifier and Its Applications," *Paper Trade J.* 108, No. 16: 33–40 (April 20, 1939).
3. Butler, W. T., "The Use of the Bauer-McNett Fiber Classifier," *Pulp & Paper Mag. Canada* 49, No. 3: 133–136 (Feb., 1948).
4. Reed, Arthur E., and Clark, James d'A., "An Instrument for the Rapid Fractionation of Pulp," *Tappi* 33, No. 6: 294–298 (June, 1950).

Measurement and Control Conference

Cleveland, Ohio, May 21–22, 1953

L. A. Moore, Moderator (The Black-Clawson Co.): The Lake Erie Section of TAPPI in cooperation with the Cleveland sections of The American Society for Quality Control and The Instrument Society of America extend to you a most hearty welcome to this two-day conference of "Measurement and Quality Control."

Your presence and interest in past May meetings have challenged the Lake Erie Section to continue in their efforts to bring to you subjects of value and interest which are paramount today. Last year many of you will remember the conference on packaging with its timely subjects, discussions, and field trips.

This year, the program committee has prepared another equally interesting program with time allotted for your participation in question and discussion periods.

In addition, you will be interested in the many displays set up in the lobby. Tomorrow, field trips to a number of prominent industrial plants have been arranged and for those who would like to make similar trips without walking, they can do so in an arm chair by watching movies.

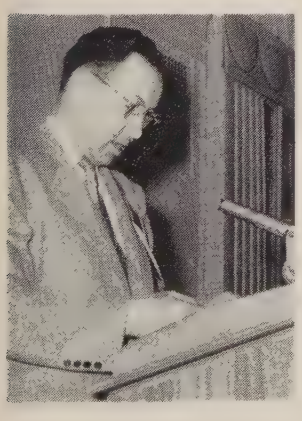
The purpose of this conference is to foster a better understanding and relationship between the supplier and the user of indicating and control instruments needed in our industry today. This meeting has been designed to be of help to the practical men in the paper industry, the plant manager, the superintendent, and those men who are responsible for production and face the daily problems of running the paper mill or converting plant.

I need not remind you of the problems you are faced with every day as a result of our present world conditions. Today, competition is more keen than a few years ago. Our plant equipment must be more efficient and dependable. Old equipment must compete with the new. As a result, the old equipment is being rebuilt, changes in new design are being made, supplement equipment is being added, and today our equipment must and is producing more than ever dreamed of 15 to 20 years ago. Yet with this increase of production, the demand for better quality is more pressing.

Another problem facing the operator is manpower to run the equipment. Some of us hardly remember the time when papermaking was truly an art. The papermaker had few, if any, instruments to help him with his daily tasks. He had to rely on the human senses given him by his Maker to guide him with the functions to make his product. This was also true in the converting field.

Today, many of the living old artists have moved to higher positions or retired, leaving few to fill present front-line requirements. These men learned the art of papermaking through years of service. One must remember that many of the younger operators have had their careers interrupted by military service and with industrial progress moving as rapid as it is today, find themselves lost in the operation to which they return.

Something must be done to meet the requirements before us. It has been this challenge which has fostered the program committee to choose as its theme for this conference, "Measurement and Control of Paper and Paperboard Manufacture and Conversion—Present and Future."



L. A. Moore, The Black-Clawson Co.

R. W. Peters, Eastman Kodak Co.

Some Practical Applications of Measurement and Control Instruments in a Paper Mill

RALPH W. PETERS and BRUCE W. HUSTON

It is said that an expert on a subject is one who is away from home. That definition admirably fits my presence before you and I would like to dispel any thoughts you might have relative to my being a control instrument expert. From my experience I can relate what we have done with process controls and how they work, but I am sure many of you know of uses of controls of which I have never heard. In presenting the following material I hope that it will stimulate thinking and imagination of the really unique applications that can be made of process measurements and controls.

I do not think it will be necessary to go into a detailed description of the older or well-known instruments, or the packaged units sold by instrument makers for measuring and controlling paper weight and thickness, material weighing, pulping, steam and water flow, speed, temperature, pH, jordan and beating power, and beating cycle. Therefore, the examples of the applications of these instruments that I will cite are in the main unusual ones which we have developed through our engineering and instrument groups.

WATER METERING

The first application I would like to discuss is the automatic measuring of water in a batch make-up operation. Figure 1 illustrates a new type of water meter which now does the job mechanically which we had to do pneumatically for a number of years. The number of gallons desired is preset on the dial near the hands by means of a knob at the upper right of the face. The valve lever is then pushed toward the meter and it automatically shuts off as the hands reach the desired number of gallons. The hands are then reset to zero by means of the knob on the right of the meter case. The secondary lever on the valve handle is an emergency shutoff. The meter can be obtained in a model which totalizes the amount of water put through it, the total showing in the block near the bottom.

Ralph W. Peters, Assistant Superintendent, and Bruce W. Huston, Maintenance Engineer, Paper Mills Div., Eastman Kodak Co., Rochester N. Y.

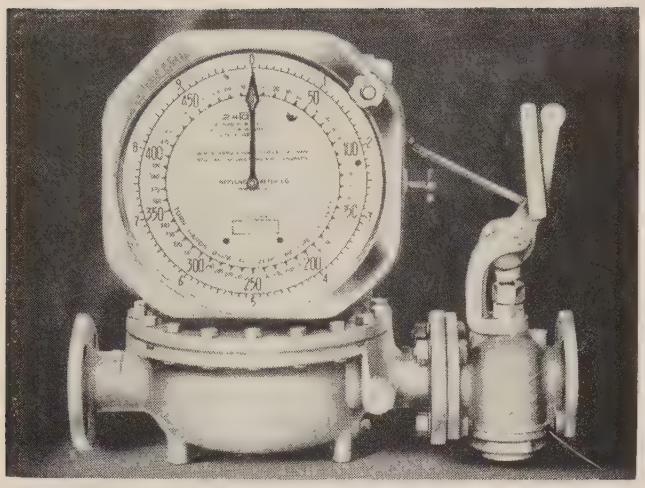


Fig. 1. Neptune auto-stop water meter

Before this new meter was available we used a pneumatically operated type. This meter has incorporated in it an air block which in Fig. 2 is shown exterior to the meter so that as the required number of gallons was delivered, the pin pushed a toggle which allowed 25-lb. instrument air to actuate a small Taylor diaphragm valve, opening up a 70-lb. air valve which actuated the main diaphragm on the water supply.

At this point I would like to digress for a moment to explain the reference I made to 25-lb. instrument air. Most instruments operate at this pressure, and when a plant has a large number, we feel it is advisable to install a separate header for this kind of air, rather than have reducing valves at each instrument. As a result, we have installed a master reducing station which consists of a filter and reducing valve installed in each of two parallel circuits. One reducing valve is set at 24 p.s.i. and the other one at 25 p.s.i. The circuit with the 25-lb. setting is the one normally in operation, but if for some reason this circuit fails, the 24-lb. reducing valve will take over. The station is inspected periodically to see that it is operating correctly. Not only does this eliminate the installation of individual reducing valves, but it eliminates the possibility of any one of many of these valves failing. It also minimizes possible tampering with reducing valves at each instrument.

To get back to the water meter, with this type the hand is turned counterclockwise to the desired number of gallons to be delivered or up against a preset stop and when the hand traveling clockwise reaches zero, the pin sets the air block in motion. We still use this type as we feel it is better suited to an operation where both filling and flushing water is used; the newer type would require resetting the small dial. It also has the advantage of the more positive diaphragm operated valve.

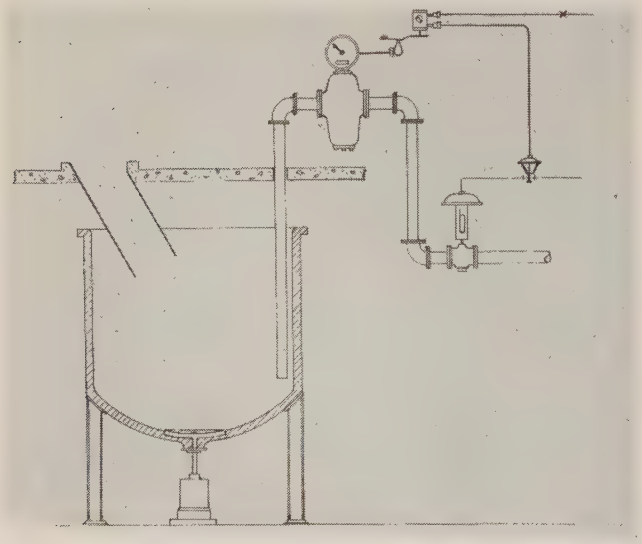


Fig. 2. Air-operated auto-stop water meter

The last two examples of water metering have been simple ones and I would like to show how, with a little ingenuity, the principles can be applied to a more complicated job. As shown in Fig. 3, we have a battery of size make-up tanks in which we want to measure the correct amount of make-up water. We have taken one of the new type Neptune meters and have coupled the valve lever to a quick opening valve in a take-off from the instrument air line. When the water valve is opened after presetting the desired amount of water, the air, operating through a selector switch, which is merely a four-way valve, opens the proper reverse acting diaphragm valve. When the water valve is automatically closed by the meter, the diaphragm valve is also closed so that the system is in readiness for the next make-up. The use of the auto-stop meter allows the operator to do other work, such as opening bags of chemicals as the water is being furnished, since it relieves him of the attention time of watching the level of water in the tank. The four-way system makes one meter do the work of four.

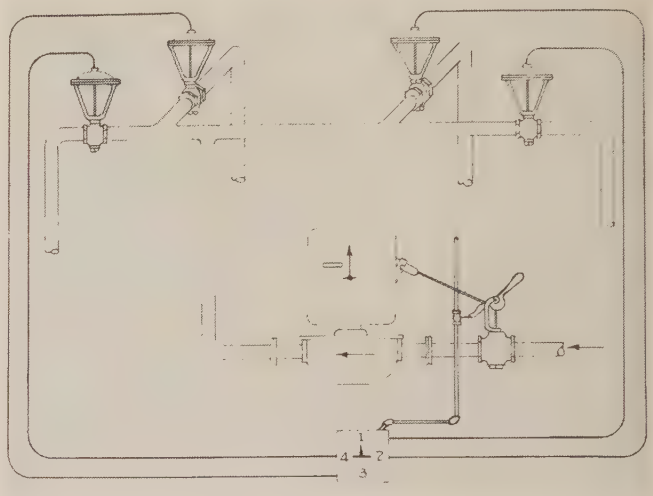


Fig. 3. Water measuring to battery of make-up tanks

STOCK DISTRIBUTION SYSTEM

Another selector type valving operation is the one applied to our stock distribution system from our hydrapulpers. We have two hydrapulpers; one supplying a 100-in. machine and a 50-in. machine and another supplying three 50-in. machines. The latter system is shown by Fig. 4. In this system the pulped stock can be selectively pumped to one of three chests.

The system is pneumatically operated, the large rectangles representing air blocks which take the instrument air impulses from the panel board and open the 70-lb. air lines to the under side of the pistons; in this case, the fourth from the left. This is an air operated Shartle quick opening valve. Air pressure is normally on the top of the piston to keep it closed. At the same time, micro switches at the ends of the valve travel energize the electric signal light system illuminating the light under no. 3 chest buttons. The valve can be closed by pushing the lower button which puts air on top of the cylinder.

If one desired to pump stock to no. 1 chest, the upper button would be pushed. This would close valves 2 and 4 and open valves 1 and 3. The electrical interlock would illuminate the

light under no. 1 button. We found the micro switches and lights necessary to detect any sticking of the valves. Air pistons are necessary because diaphragm motors do not have enough travel for a large gate valve.

LEVEL CONTROLS

The third application I would like to discuss is the maintenance of liquid levels. I think the use of level controls in our mill has improved operation more than any other one kind of instrument. Figure 5 represents a typical installation, keeping a jordan full and keeping the jordan pump suction flooded. In order to obtain the maximum output of a jordan it is necessary to keep it full so that stock surrounds all the blades. In the past this has been done by having an overflow dam after the jordan, usually a small box with boards in slots so that the head could be controlled. This system was quite satisfactory, but still did not keep full a jordan with a high pumping characteristic. By maintaining a level in a headbox ahead of the jordan and throttling a valve on the jordan outlet, the stock output of the jordan can be controlled to the input rate. In the diagram, metered stock from the stock gate flows into a funnel on the jordan inlet. A level control in this funnel operates the outlet valve.

This is how the instrument works. Twenty-five-pound instrument air enters the panel at the lower left-hand corner.

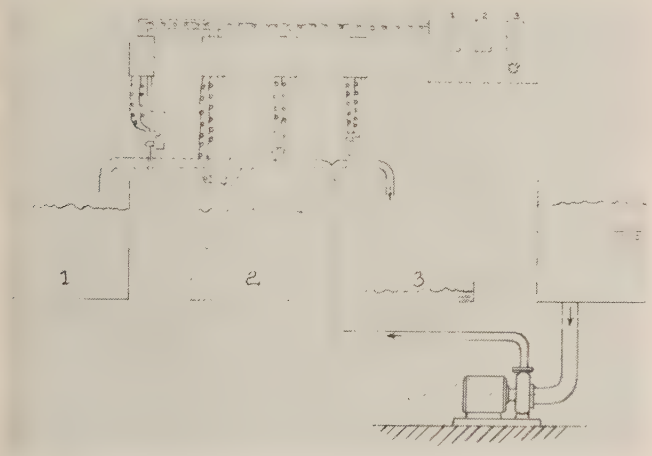


Fig. 4. Stock pumping distribution system

Some of this is bled off through the right-hand needle valve and goes to a bubble tube which is submerged in the stock in the funnel. The amount used is governed by the amount necessary to keep the bubble tube free of stock. The air pressure necessary to counterbalance the head of stock over the bubble tube outlet is transmitted to the bellows of the sensing element at the top of the panel. The action of the bellows controls the pressure of a small portion of 25-lb. air which is continually supplied to the top of the element by means of the left-hand needle valve. This pressure is transmitted to the cross-shaped air relay near the center of the panel which controls the pressure of a larger volume of 25-lb. air and sends it to the spring-loaded diaphragm motor operating a Hills-McCanna valve on the jordan outlet. The level to which the instrument will control can be adjusted either by the knob on top or by changing the bubble tube submergence. These instruments operate in the range of 0 to 2-ft. head over the bubble tube outlet but are more accurate when operating in the middle of the range.

The other instrument operates in the same manner to maintain a level in the pump box into which the jordan discharges. This not only keeps the pump suction flooded to minimize foam formation, but also keeps the flow of stock to the machine constant and not fluctuating due to different levels over

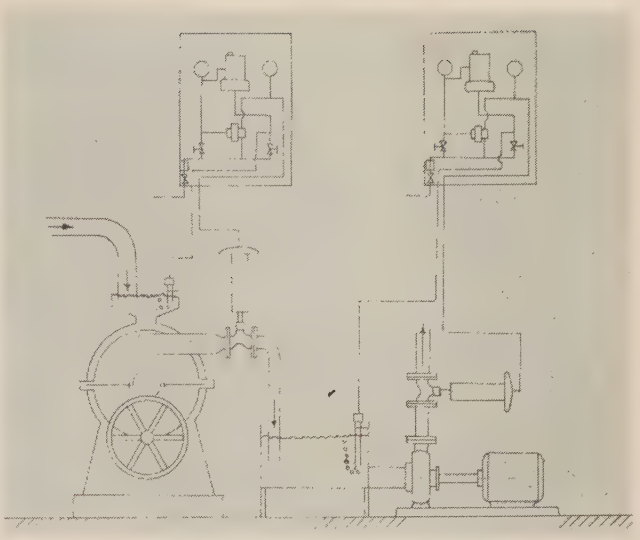


Fig. 5. Jordan and pump box level control

the suction or to the pump air binding. This same principle is applied by us to maintain a level in the wet trim pit by throttling the wet trim pump, to maintain a level in the recirculating or inlet box ahead of a Vortrap or Dirtex installation, to maintain a level in a machine stock chest by throttling a pump from the beater chest, and to maintain a level in the size tubs. You will also see that it is an integral part of the next system that I will describe.

CHEMICAL MEASURING AND FURNISHING SYSTEM

I think the control installation about which we are most proud is one that automatically measures and adds sizing chemicals to our stock. We had made great strides in eliminating beater room labor by replacing beaters with jordans and hydrapulpers into which weighed units of fiber were

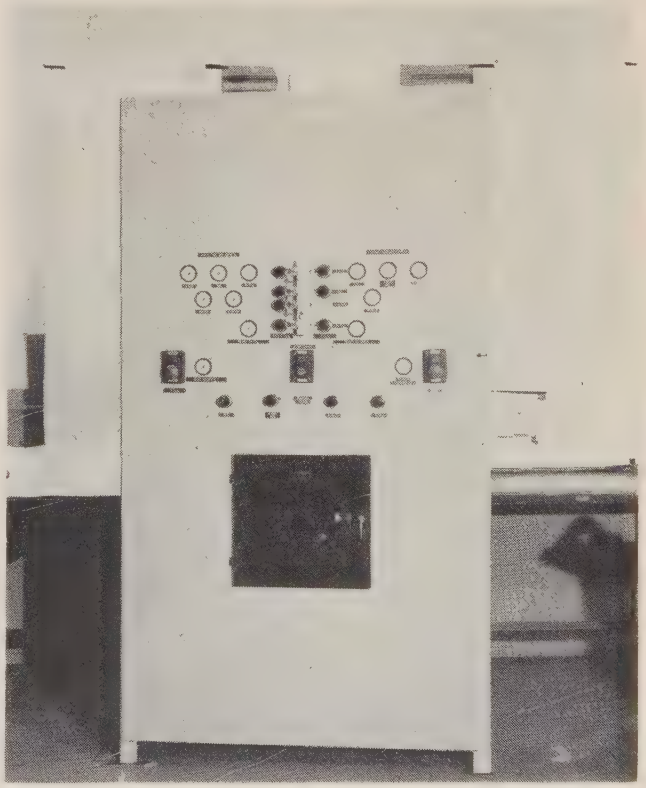


Fig. 6. Panel for size measuring and addition system

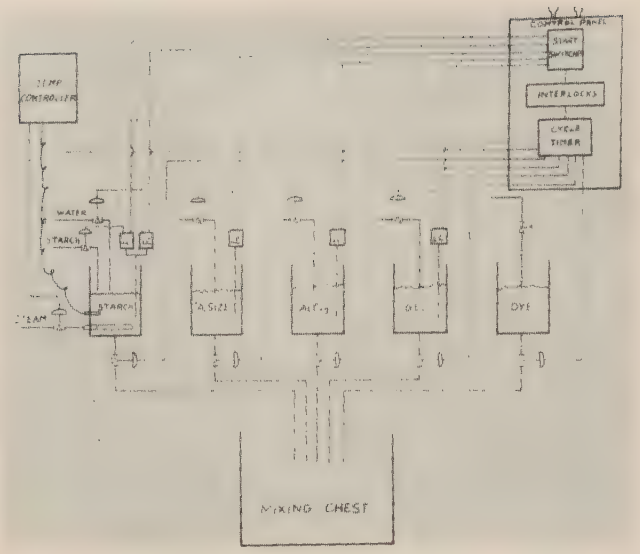


Fig. 7. Diagram of instrument hook-up for size measuring and addition installation

automatically dumped. But we still had the manual job of filling the size measuring tanks and dumping them, one by one, into the mixing chests. Coupled with that, we knew that accurate measurement of chemicals was not always attained, nor was the proper schedule of mixing between chemical additions always adhered to. And then there was the inevitable slack-sized or double-doped chest. I don't suppose you men have that trouble. That led us to engineer the following automatic system which has further reduced labor.

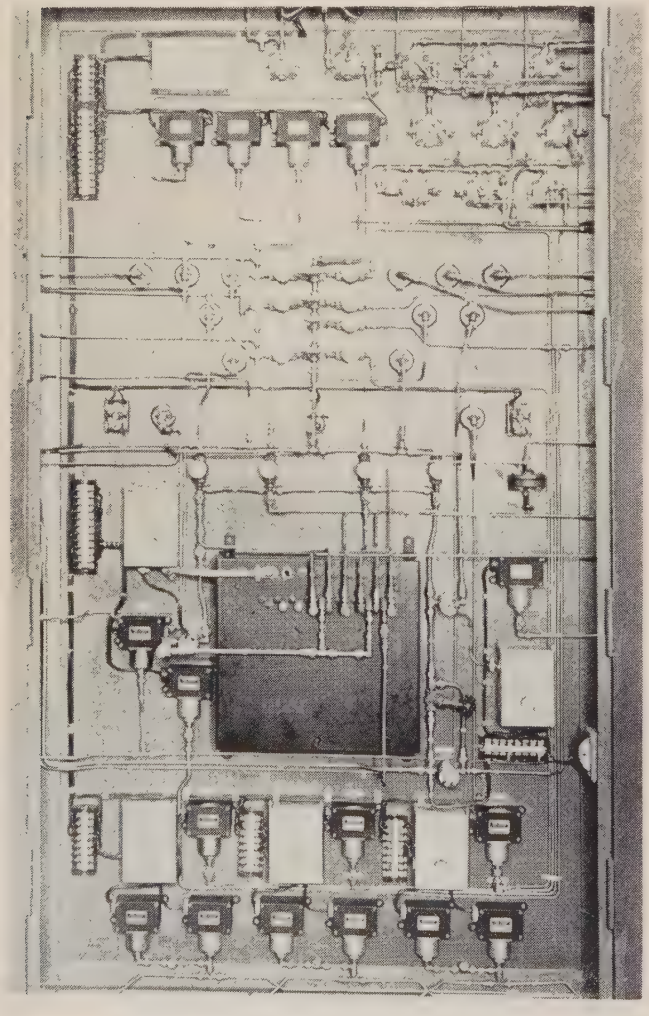


Fig. 8. Back of panel for size measuring and addition system

Figure 6 is a view of the control panel for the system for our large machine. The operator actuates this system by pulling the handle in between the gages which, by means of stops, pulls out one, two, three, or four buttons, depending on the chemical furnish desired. When the measuring tanks are full, as signified by a green light on top of the panel box being illuminated, he starts a cycle timer which adds the chemicals in a definite time cycle by pushing the "drop" button just below the "fill" handle. The other buttons are for manual operation, the gages by air pressure indicate the progress through the cycle, and the other light, which is red, indicates a power or instrument failure so that the operator will not pump over this stock, assuming that it has been properly doped.

Figure 7 is a diagrammatic sketch of how the system works. By pulling the "fill" handle, air switches supply air pressure through the level controls to the reverse acting diaphragm fill valves to open them. When the proper level is reached in each tank, the level controller bleeds off the air, closing the valve, and setting the proper interlock. You will notice that

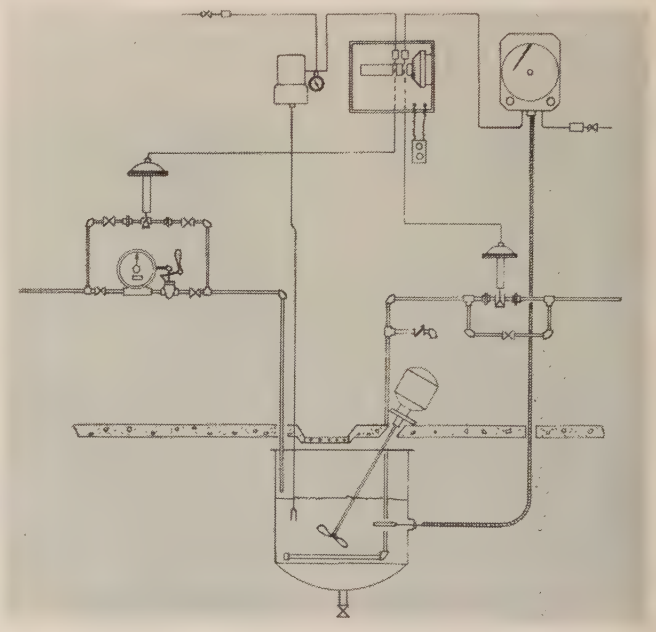


Fig. 9. Starch tub-size make-up system

the starch tank requires both starch slurry and water. When the proper water level is reached the level controller shuts off the water fill valve and opens the starch valve which is shut off by a second controller.

Pushing the "drop" button starts the cycle timer which merely supplies air pressure at preset times to each of the reverse acting diaphragm valves to open them and also to open the starch cooking steam valve. When the correct cooked starch temperature is reached a Taylor Fulscope temperature controller closes the steam valve. If the starch is not cooked when its drop time in the cycle is reached the cycle timer turns off until the cooking is complete, at which time the timer resumes the dropping cycle. Upon completion of the cycle the timer bleeds off the air to these valves, allowing them to close with the exception of the starch drop valve for the next fill. The starch tank is washed down and the valve closed after this operation by throwing an air switch. This action is also interlocked so that the tank cannot be refilled until the drop valve is closed. This installation is complicated, as shown in Fig. 8. The air blocks, solenoid valves, and interlocks are clearly visible. The installation cost about $35,000 but was easily justified from the standpoints of labor saving and improved quality.

TUB SIZE STARCH COOKING

Another chemical preparation application of instrumentation is that of tub size starch make-up, as illustrated by Fig. 9. A measured amount of water is first put into the make-up tank by means of the auto-stop meter at the left. The agitator is started and the correct weight of dry starch is dumped into the tank. The operator then starts the cycle timer in the panel at the top of the diagram by pushing the "start" button and walks away.

The timer turns on the steam by sending air pressure to the reverse acting diaphragm valve. When the starch has been cooked to the correct temperature, as indicated on the temperature controller, the air pressure is bled off the diaphragm valve by the controller and it closes, the check valve above the mixed motor prevents starch from being sucked into the steam line by the vacuum created by steam condensing in the line. After a short interval the cycle timer sends air to the reverse acting diaphragm water valve on a by-pass around the meter. This turns on the diluting and cooling water. It is added to a level by the usual level controller which, when the correct level is reached, bleeds off the air in the water valve diaphragm to close it. The size is then drawn off to a holding tank when the operator is next in the room.

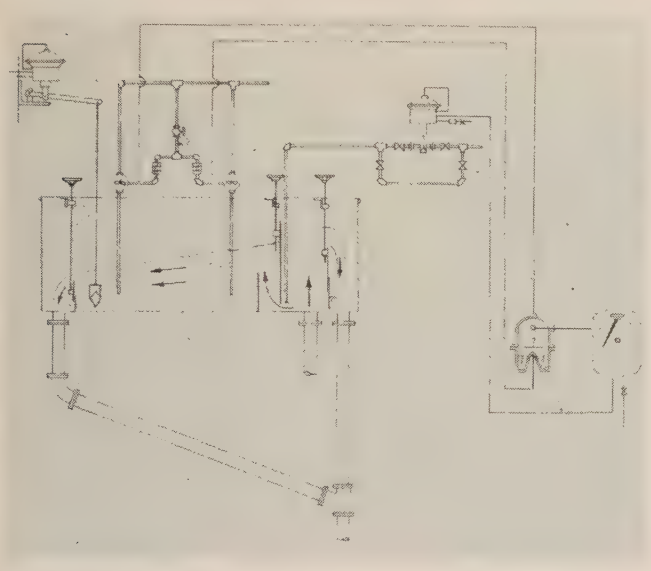


Fig. 10. Consistency control installation

CONSISTENCY CONTROL

After considerable investigating we decided on the Brammer regulator (Fig. 10). This instrument operates on the principle of head loss of stock flowing in an open channel. The level of stock at the beginning and end of the channel is a measure of the consistency of a given fiber furnish.

To operate the instrument, the desired consistency is set by moving the set pointer on the recording controller at the lower right of the diagram. This establishes the desired differential of level in the channel and this is measured by the two bubble tubes at the beginning and end of the channel. Air is constantly leaving the bottom of the bubble tubes as adjusted by the air valve ahead of the bubble tube Y. The pressure necessary to force bubbles out of the bottom of the tubes is transmitted back to the type 9 or Foxboro bell differential instrument shown next to the controller. This then regulates the air pressure on the diaphragm motor which is connected through a Precisor to a reverse acting water valve which adds the correct amount of water to the incoming stock to give the proper channel level differential. There are three-way valves in the bubble tube system so that, if necessary, full line pressure and volume can be blown through the tubes to purge them.

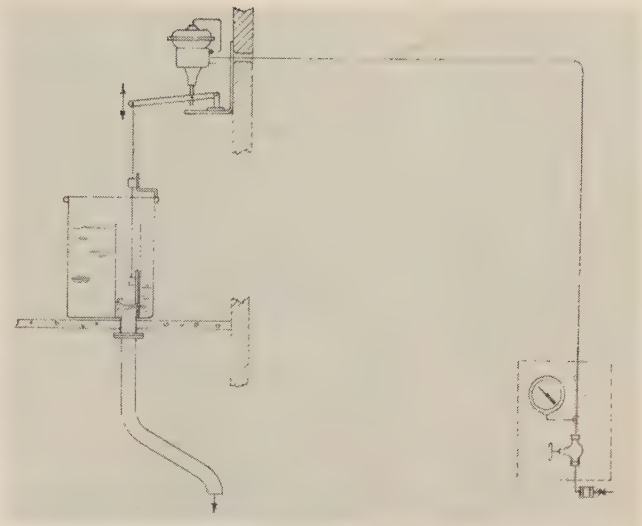


Fig. 11. Stock gate remote control

This is the first time that the Taylor Precisor has come into our discussion and perhaps a word about it is in order. This instrument merely insures the proper position of the valve stem for a given air pressure signal. The trouble we had encountered was that for a given air pressure the diaphragm motor did not always set itself to the same point due to sticking of the stem and changing line pressures. The Precisor compensates for this by increasing or decreasing the air pressure on the diaphragm until the proper position is attained.

I have not gone into the details of the stock flow in the regulator because positioning of the dams is dependent on stock consistency range and machine demand and is therefore a papermaking problem. I would like to call your attention, however, to the stock gate connected through a lever system to a diaphragm motor at the upper left-hand corner of the diagram, as this is the next item to be discussed.

STOCK GATE CONTROL

Perhaps others of you are using similar remote stock gate control instrumentation. It is a simple system, illustrated by Fig. 11, but we have added one refinement of note that has eliminated considerable malfunctioning formerly experienced.

Twenty-five-pound instrument air is put through a manu-

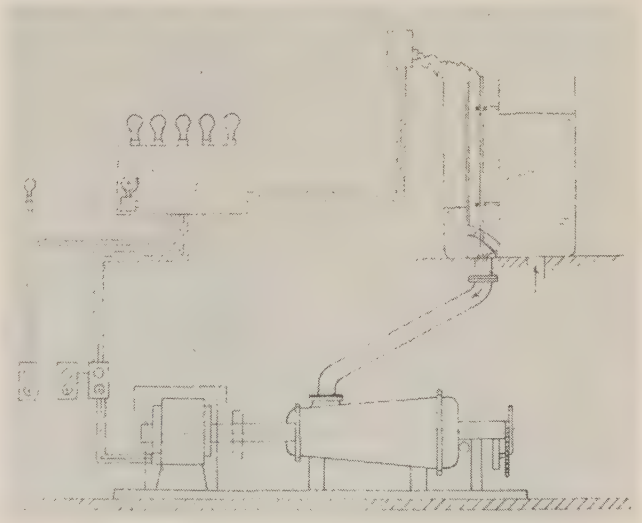


Fig. 12. Automatic jordan protection

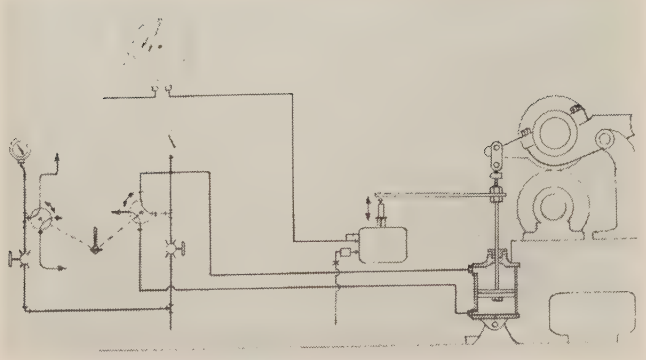


Fig. 13. Pneumatic press loading

ally controlled Taylor reducing valve operating in the range of 3 to 15 lb. pressure, the reduced pressure registering on a gage that can be graduated in pounds of stock per hour. This pressure then moves a spring-loaded diaphragm motor a certain amount which, acting through a lever system, positions the sliding member of a Diamond stock gate, shown here at the end of the consistency regulator channel. The refinement is another example of the installation of a Precisor on the stem of the diaphragm motor. Here again we were having trouble with the diaphragm motor not duplicating its setting for a given air pressure, due to sticking of this stem or variation of friction in the stock gate. The Precisor will accurately position the stock gate for a given air pressure setting at the machine tenders' bench.

AUTOMATIC JORDAN SHUTDOWN

The problem of jordans running dry has always been a serious one, particularly if they are set up and being used hard. Figure 12 illustrates a device we have installed on our jordans to detect this and shut them down before any damage is done. It merely consists of an electrode arranged so that the stream of stock leaving the stock gates impinges on it. As long as it does so an electric circuit is maintained, but as soon as it is interrupted a relay shuts down the jordan, starts an alarm bell ringing, and illuminates a light on the panel board to indicate the jordan that shut down.

In starting up a jordan, the machine tender pushes the start button of the right-hand box of the three at the lower left-hand corner of the diagram. After stock is going through the jordan he throws the switch in the left-hand box which in reality is a toggle switch. This illuminates the small pilot light to show the circuit is energized. In this state, if the flow of stock ceases, only the alarm sounds and the light is illuminated. In order to automatically shut down the jordan he would have to push the "automatic" button in the center box to take if off "manual" operation. This choice between "automatic" and "manual" we think is necessary so that the jordans can be operated to keep the machine going in case the signal system breaks down.

The same alarm panel can be enlarged to indicate trouble at other spots, such as lubrication pump failure, low chest level, etc.

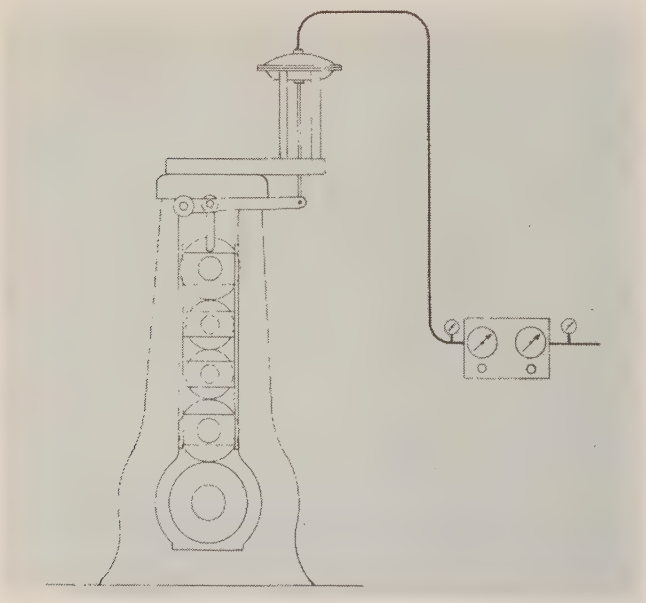


Fig. 14. Pnematic calender loading

PRESS AND CALENDER LOADING

Press and calender loading is another instrumentation job. We pneumatically load presses with both diaphragm motors and pistons. The decision of which to use usually depends on the movement that is necessary to adequately raise and lower the press since the diaphragm motor has a limited stroke. Figure 13 illustrates a piston and cylinder installation on a smoothing press. Seventy-pound air enters the system at the bottom left of the diagram, it passes through a reducing valve, and then through a two-way valve which directs it either to the top of the piston for loading or to the bottom for raising the press. Actually there is an intermediate position also which unloads the press. A second reducing valve and two-way valve take care of the other side of the press. The amount of loading on each side can be obtained by adjustment of the reducing valves. The system could end here with an instrument recording the pressure on each side of the press. The two-way valves can be tied together by a mechanical linkage, as shown.

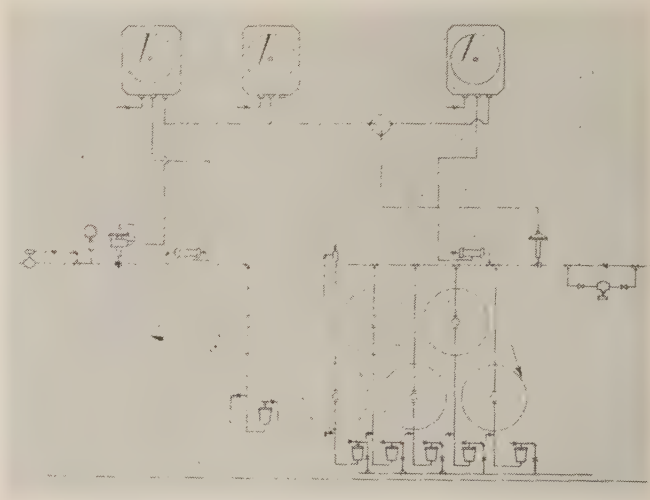


Fig. 15. Drying control system

Actually we have an added refinement on some of our presses which includes the installation of a Precisor. This has the advantage of not only weighting the press accurately, since from my previous discussion, you remember, I showed that a Precisor will counteract variations in friction of the moving parts in the mechanism, but also will position the roll so that it is level from side to side. This is of particular advantage when highly crowned rolls are used, due to high weighting or soft rubber; a Yankee drier pressroll, for example. In the diagram, extensions of the press roll arms act on the plunger of the Precisor and air pressure is either added or subtracted by the Precisor until the roll is positioned at the preset reading on the recording instrument. In such an installation the Precisors must naturally be frequently calibrated to compensate for roll wear and for roll changes. We do this by placing

paper and carbon paper in the nip, applying pressure to each side of the press until a uniform nip impression is obtained, and then adjust the Precisor plunger to zero in it.

This is a specialized application and one that is not often warranted, but I mention it in passing to show what can be done.

Figure 14 shows a diaphragm motor used to weight a calender stack. Here part of the old lever system has been utilized and the diaphragm mounted on top of the stack to replace the rod that formerly went down to the weight lever. The size of the diaphragm motor depends on the calculation of force necessary to obtain normal loading and on the air pressure available.

Air enters the panel through adjustable reducing valves and the loading is recorded by pressure gages on the front and back diaphragm motor air supply line. Not shown is a quick unloading lever which immediately releases the air pressure in case of a break or crease or wad.

We like the use of diaphragm motors whenever possible because there is less possible binding of the moving parts. Cylinder and piston installations have given us some trouble because of binding of the piston in the cylinder and piston rod in the packing glands so that a given air pressure does not result in a consistent force application.

DRYING CONTROL

The last example of instrumentation I would like to present is that of automatic adjustment of drier section steam pressure to control drying to a given moisture content. Most of these installations are on the last section of driers to control finished sheet moisture content but we also have installed one on the first section to control moisture to about 25% at an embossing press. Barring wide variations in machine speed, sheet weight, and stock condition, the moisture controller will controll to ±0.2% moisture content.

In Fig. 15, the last drier in the section has been singled out as an indicating drier. In the diagram this is the one off by itself at the middle bottom. Care must be taken that the siphon pipe and trap of this drier are in perfect operating condition. The steam supply to this drier is reduced to a constant 30 lb. and then controlled in the drier at 5 lb., although this can be varied to meet individual mill conditions. As the paper comes wetter or dryer to this drum, increases or decreases in condensation rate will cause slight decreases or increases in pressure in the drier drum. This change in pressure is transmitted through a surge tank to the instrument at the top left which changes the air pressure on the spring-loaded, Precisor-controlled diaphragm valve in the indicating drier steam supply line to re-establish the 5-lb. equilibrium. The air pressure necessary to do so is recorded on the center instrument and is an indication of the moisture content. This air pressure impulse is converted by the instrument to control the air pressure on a spring-loaded diaphragm valve in the main drier section steam supply line and alter the steam supply accordingly. As the supply is throttled, the pressure in the driers will change with load changes and this pressure is recorded on the right-hand instrument.

When the paper machine is started up the two-way valve between instruments 2 and 3 is turned to the other position. This puts the system on manual control and the right-hand instrument maintains constant pressure in the section as determined by the second manual set pointer. The back tender will adust this pointer until the moisture content of the paper feels right, or an analytical moisture test shows it to be correct. The air pressure on the diaphragm motor necessary to accomplish this is noted on the usual dial gage and the manual set pointer on the center instrument is set to give an output of the same pressure on this instrument dial gage. The two-way valve can then be turned to "automatic." This throws the drier section steam control onto the middle instrument through impulses received from the first instrument and locks out the third instrument which now merely becomes a recorder.

The setting of the pointer on the middle instrument now becomes the moisture content determined analytically and as the recorder pen wanders to each side of the preset line the actual moisture content can be interpolated, knowing the calibrated relationship between each line on the chart and the fraction of a per cent moisture content it represents.

I hope this paper has given you some ideas and perhaps may have raised some questions in your mind, the answers to which may stimulate an improvement to the existing art, or develop a new application. We have two and a half instruments per operator but I know we are not through yet. Their use is one answer to high labor costs.

Q. What method do you use for continuous addition of chemicals?

A. We have used rotameters in one application.

Q. Is the dyestuff addition made from a small tank?

A. Yes. This is a small tank and the dyestuff is dumped into the tank (not a continuous addition).

Q. What starch concentration is used and to what temperature is it carried?

A. A starch concentration of 1 lb. per gal. is used and it is brought up to the gel temperature.

What the Papermaker and Converter Would Like to See Measured and Controlled

WILLIAM H. AIKEN

When I was approached about this meeting several months ago, I was asked to dream a little about things that might be automatically controlled in the manufacture and conversion of paper. This is certainly a very broad area in which to dream. In order to bring our dream down to earth, we will try to confine ourselves primarily to fundamental dreams. Perhaps you are not acquainted with fundamental dreams. They are as simple as this: do not dream about things that you would like to buy if you had the money, but rather dream that you have an oil well in your back yard. Then, you can buy the things you want. That dream of an oil well is a fundamental dream.

I am dreaming of the day when papermaking is approached as a science and not as an art. If we define science in terms of cause and effect, then papermaking must be classed as a science, even if one in which many of the causes for the end results are known. Full benefit can be derived from process control in the paper industry only when papermaking is considered from the scientific approach. This approach must extend throughout the organization, including the machine crew.

Many of you have either met or heard of the old-time papermaker. He ran his machine with a bag of tricks that he carried in his head or in a little black book; your life and health were in danger if you tried to pry into how he ran his machine. His "know-how" was his job security, and he intended to preserve it. Fortunately, this type of machine tender is vanishing, but he is not completely gone. In some cases, he is just a little more modern. I know one machine tender who has a standard answer for any change he makes. "I just put a little Duz in it. You know, Duz does everything."

Most machine tenders today are willing to have you observe how they run their machines, but many cannot tell you exactly how or why they run the machine as they do. To them, a paper machine is a temperamental, almost animate, object which is just a little smarter than you and always one jump ahead of you. This type of machine tender tries to out-

William H. Aiken, Technical Director, Gardner Board & Carton Co., Middletown, Ohio.

guess the machine. When something goes wrong, he makes a dozen changes in hopes that one will clear up the trouble. He usually never knows which one of these changes did clear up the trouble.

Finally, there is the machine tender who is a scientist, whether or not he realizes it. He knows that there is always a cause or combination of causes for any condition that exists on the machine. When trouble arises, he systematically checks through the possible causes and eliminates them one by one until he gets to the trouble. Of course, he does not always hit the answer immediately, for the many variables of a paper machine give a large number of combinations of variables to give any end results. This type of machine tender has true job security in his thinking ability.

In our mills we keep a record of the amount of broke and offgrade board made on each machine. Since folding boxboard manufacture is a specialty business, there may be dozens of changes in grade, caliper, coating, and color on a given machine in a week. Allowances must be made for these changes in calculating what the normal broke should be on a machine. In setting up the standards, we let our operating people set their own times for change-over so that we know these standards are fair. We keep a weekly record of crew performance and the performance of any one crew varies from week to week. It is not always easy to determine all of the factors that affect a crew's weekly production; however, one crew is always outstanding. The machine tender, who has 35 years' experience on the machine, is strictly a cause and effect man. Many contribute the good performance of this crew to the ability of the other members of the crew. This is certainly a contributing factor. The machine tender has taught them to think in terms of cause and effect, and they are a close-knit team.

An instrumentation program can be most successful with a crew that thinks in terms of cause and effect. No matter how good a control instrument may be, it is of little value unless accepted by the crew and used properly. A cause and effect crew realize that good instruments can control some of the variables that cause trouble on the machine. The more of these variables under automatic control, the less the undesirable effects that arise on the machine. The crew can then spend their time and skills on the finer points of machine operation to produce more and better paper, and, therefore, increase their take-home pay.

EMPOYEE RELATIONS IN INSTRUMENTATION

The degree of success of an instrumentation program on a machine is very dependent on the attitude of top management and the way this attitude is conveyed to the man on the machine. Any dream of the ideal system for instrumentation must then include dreams of the management attitude toward instrumentation. I am dreaming of the day when management and employees both realize that they both have the same objectives, and that the production of larger quantities of goods of higher quality with less physical exertion, and to be sold at a good profit, bring security to both the company and to the man's job. It is up to management to convince its employees that this is true. This must be done both by deeds and by communications. An instrumentation program can be most successful if the men in the plant are convinced that the use of the instruments will make their jobs more secure. This is the approach of job security through technical improvement. To accomplish this, management must work on the premise that most people want to do a good job, and that they will cooperate in any constructive program if it is fair and they are given the facts. This means that management should tell people about changes that are being made, why they are being made, what they cost, what they mean to the working man in terms of job security, and what they mean to the company in terms of competitive position. It means that management should not use technical improvements to lay off people or to affect their earning opportunities.

Many of you probably think that this is the wildest dream of all. Actually, it is a realistic, down-to-earth approach to employee-management relations that works. Its successful operation greatly simplifies an instrumentation program.

It is easy to dream of improvements to be made in management policies and in the machine crews' attitudes and understanding; however, we must now get a lot closer to home for many of us and dream about the day that we are not so technically ignorant about the things we want to control. Our ignorance covers a great many fields.

First of all, there is a great gulf between the knowledge and understanding of the machine tender and that of the technical man. It is one thing to observe an operation, and speculate how it should be done, but quite another thing to perform the operation with your own hands and put the changes into effect. On the other hand, it is often difficult for a man who has spent his life on a machine to understand and appreciate the technical approach. Fortunately, there are a great many people in management jobs in our industry who worked up from the machine and who have acquired a good technical understanding. Unfortunately, in many cases, it has been so many years since these people have worked on the machine that they have lost much of their first-hand knowledge.

One approach is to put technical men on the machine, not as observers but as operators. We have a Ph.D. in our department who worked as a machine tender for 4 months. Then he worked as tour boss for a similar period. This experience has been invaluable in our instrumentation program. For example, some of our machine tenders feel that even considerable variations in consistency do not greatly affect machine operation; they feel that through their experience they can minimize the effect of consistency variation. The technical man on the machine realized that allowances could be made for consistency variation, but he felt that at least 50% of the trouble on the wet end arose due to variations in consistency.

Another method of eliminating ignorance is through intelligent use of data accumulated by a good quality control system. Many use the quality control department for quality measurement rather than for control. While this is a worthy effort in itself, it is rather wasteful of the time and effort that went into collection of the data. Actually, the data collected by a good quality control system can be the eyes and ears of the technical department. These data can be used to point to technical improvements that need to be made. Progress made by these improvements can be followed. Finally, it can point out poor operating practices in specific operating crews.

Even with the aid of technical people operating the machine and the full use of good quality control data, we must dream of the day when we understand better some of the factors that affect our end properties. Our dream also includes ways of continuously measuring these properties and automatically making adjustments to keep them within the tolerances we desire.

DESIRABLE POINTS FOR INSTRUMENTATION

Few companies in the paper manufacturing and converting industries have made full use of the instruments available to them. However, if all of the available good control equipment were installed in one mill, that mill would still be a long way from a push button mill. I would like to list a few things that we would like to see automatically controlled in our plant. Other companies can probably add many more.

Refining. We would like to be able to control refining to give a stock that forms up right on the wire and that gives the desired properties in the finished sheet. Perhaps an automatic freeness tester would be a step in the right direction. The approach is complicated because we use two types of re-

fining equipment in series, all of our furnishes contain two or more types of pulps, our running speed may vary twofold from day to day, and we run several hundred different furnishes.

Bender. In the folding box industry, we must be concerned with the bending qualities of board, for folding boxboard must be scored and creased without rupture of the liner. Bender can be affected by many factors including furnish, degree of refining, and the manner in which the sheet is dried. An instrument to automatically measure bending qualities and to regulate the factors affecting bender would be highly desirable.

Wet-End Tension Control. In order to obtain efficient water removal from the sheet and eliminate breaks on the machine, correct tension must be maintained between the various driven elements of a machine. The automatic tension control devices available cannot be used on the weak wet sheet in the press section and first sections of the drier stack.

Bonding Strength. A cylinder sheet is a composite of a number of sheets that must adhere to each other. Ply adhesion is affected by furnish, refining, beater additives, and machine variables. On both fourdrinier and cylinder sheets, internal bonding is often a problem. A good method to measure bonding is needed; one which automatically measures and controls this property would be very desirable.

Weight Distribution Across Plies in a Cylinder Sheet. In order to produce a sheet of good surface and printing characteristics with adequate strength, yet, at reasonable cost, the manufacture of cylinder machine board often uses four different furnishes in the same sheet. To utilize each of the furnishes to best advantage and to produce a uniform sheet, it is highly desirable that each ply be uniform in weight across the machine. Since the plies in a good board are adhered firmly to each other, they cannot be easily separated. There is a great need for a method for determining the weight pattern across each ply. An instrument that would automatically measure the weight distribution for each ply would be very valuable.

Brightness. In recent years, designation of brightness in paper and board has become almost as standard as designation of weight and caliper. It is possible to control slight variations in brightness of a furnish by adding a slurry of titanium dioxide at the headbox. Before this can be done continuously and automatically, an instrument that will automatically measure brightness accurately is required.

Color of Paper. Color control of paper is necessary both on white and colored grades. An instrument capable of accurately measuring and controlling color on the machine would remove one of the difficult variables of papermaking.

Size. Many grades of paper and board must be sized for a variety of reasons. Many types of sizing tests exist, but the relationship of these tests to product performance is not always sufficiently clear. However, an instrument to automatically control the degree of sizing should be helpful in producing a more uniform product.

Physical Properties. Most boards and papers must meet some type of strength tests. These include bursting, tearing, tensile, folding, stiffness, and softness to mention a few. There is a very fertile field for work on measuring and recording these properties continuously. If such instruments existed and the factors affecting the properties were fully understood, perhaps control of these properties could be regulated from the measuring instrument.

Printability. Printing quality is important for many papers and boards. Different sets of paper properties are required for a paper to be printed by letterpress, by offset, and by gravure. Surface smoothness, internal bonding, compressibility, and ink receptivity are factors that must be considered. We must know more about how the combination of these factors affects printability. We must know how to accurately measure the properties in question. Then, we must think of how to measure the properties on the machine. After we know the machine variables that affect these properties, we can automatically control them from the measuring instruments.

Color Control in Printing. It would be highly desirable to have an instrument to measure and control color of the sheet as it comes from the press. To insure good color control, such an instrument should not only adjust for the amount of ink applied, but should also adjust for slight variations in color of ink and paper.

I have not attempted to list all of the things that should be controlled in order to make papermaking and converting a push button operation. The above examples were given merely to illustrate that this industry offers a very fertile field for instrumentation.

ACCURATE INSTRUMENTS REQUIRED

Just as the technical man and the machine tender often have insufficient understanding of both the technical and operating side of a machine, the typical instrument manufacturer knows too little about our processes, and we know too little of his limitations in producing instruments.

My most important dream about the instrument people is that they be above all else good technical people. One of the retarding factors to instrumentation has been that too many inaccurate instruments have been supplied to the industry. The use of inaccurate instruments to measure properties can be harmful; their use to control properties can be disastrous.

First of all, an instrument must measure the desired property. Definition of this property is often the most difficult problem. There are still many effects whose cause or combination of causes is not sufficiently understood. The inability to define the problem is one of the great hindrances to automatic control in the paper industry.

Secondly, the instrument should accurately measure the property in question. Far too many instruments have inherent errors in their construction which make accurate measurement impossible. Precision or reproducibility of an instrument is important, but precision should not be mistaken for accuracy. An instrument may be precise to the point that identical readings may be obtained on a given sample every time it is measured. Yet, if there is an inherent error in the instrument that causes a 20% error in the reading each time, the high degree of precision is meaningless.

Finally, if there are elements in the instruments which change properties with age, methods for compensating for these changes must be provided.

A machine equipped with automatic controls makes the job of the machine tender easier, however, because the instrument does part of his work for him, the machine tender, through lack of use, loses some of his many skills that are required to run a paper machine. When the instrument is not working, the machine tender may be hard put to operate the machine as efficiently as he did before the instrument was installed. An automatic control is a liability when it does not work.

Instrument makers should, therefore, be sure that control instruments are sturdily built from materials that will stand up in service. For example, a pH meter to control addition of alum can accurately do this job, however, if the pH meter comes equipped with a valve that is rapidly corroded by alum, it will be difficult to keep the machine in operation. Since lost time on a paper machine is very expensive, manufacturers of control instruments should be equipped to provide rapid and efficient service when required.

Q. Since you indicate that about 50% of the trouble is due to consistency regulation, what has been done to improve consistency control?

A. We have consistency regulators of a type on the filler systems. The sheet does not vary more than ±5%. We are installing a Poirier instrument which is specified to control consistency and volume within a range of ±2%. It might be men-

tioned that better machine tenders can take a consistency variation of ±12% down to ±5% on the sheet.

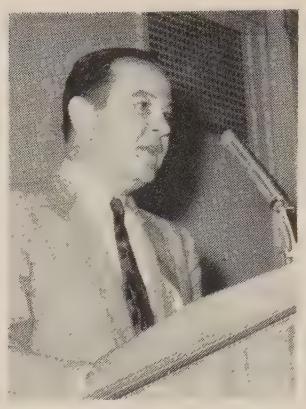
Q. Do any of the problems of consistency regulation require a range below 3%?

A. We have talked about regulating down to 1%.

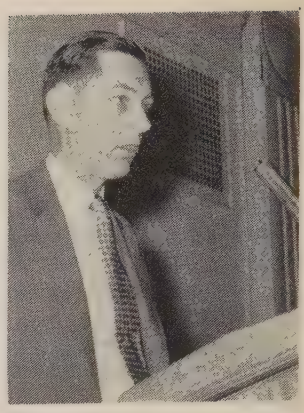
A. We have had no necessity for regulating below 3%.

Instrumentation from Management's Viewpoint

S. C. LLOYD, JR.



W. H. Aiken, Gardner Board & Carton Co.



S. C. Lloyd, Jr., E. I. du Pont de Nemours & Co.

INDUSTRIAL management today looks on instrumentation as a vital part of their plant equipment which has enabled them to produce more products of high quality at optimum yields and low cost, with greater safety. Instrumentation has also made possible the large-scale production of many products at a reasonable price that were not available a few years ago. This has opened many new fields for existing industries and helped create new business enterprises. The rapid industrial growth in this country during the past 20 years has gone hand-in-hand with the availability of better operating equipment, including a means of controlling complex and hazardous processes with safety.

There are many specific reasons why the management of any industrial concern, large or small, can easily justify an investment in instrumentation. A few of the most important are: (1) better quality and uniformity of product; (2) accident prevention; (3) accelerating the conversion of batch processes to continuous processes; (4) savings of materials, fuel, and electric energy; (5) labor saving in the sense of increasing productivity bringing about higher wages and lower prices; (6) prolonging the service life of process equipment; and (7) increasing production from process equipment.

I am most familiar with these advancements in the chemical industry, but I am sure that you have all witnessed a similar change in your industry. Many of your applications of process control and the resulting organization problems are the same as ours. My subject deals briefly with how our management has viewed this change and how we have dealt with its problems.

Not many years ago, practically all chemical processes operated on a batchwise method. This type of operation required a minimum of instrumentation. The operator was generally guided in his valve twisting by glass stem thermometers, pressure gages, sight glasses, and a vast amount of personal experience. In those days an operator had to be given many months or years of training to enable him to operate such a process properly. In fact, it might be said that the operation of many processes was possible only because of the "art and skill" of the operator.

With such manual control, the operating equipment was generally large in volume in relation to throughput to insure a high degree of stability. The operation of such steps as a chemical distillation process, or in your industry a bleaching process, required the operator to take many steps per day to check operating conditions at various critical points on the equipment. Such operations were time-consuming to say the least, and thus considerable time lags in the process were essential to permit the operator to produce a product with reasonable uniformity of quality.

In an effort to improve quality, reduce costs, and increase production, we turned to the development of continuous processes. It then became imperative that we have methods which would indicate and control with the minimum of lag, the many variables if the unit was to operate satisfactorily. During the time required to run control tests suitable for the batch processes, a continuous one may get so far out of balance as to require hours to correct, and may make large quantities of off-grade product during this time. In other cases, serious danger to personnel and damage to equipment may result.

It is a matter of record that in some processes the throughput has been more than doubled while labor requirements have been reduced to a tenth of the requirement which held at the lower rates. Instrumentation, of course, cannot be given the total credit for this achievement. More efficient pumps, corrosion-resistant alloys, better motors, better packing, better lubricants, high steam pressures, etc., all played their parts. But, it should be remembered that without adequate instrumentation, such improvements could not have been exploited to the extent they were.

The operation of a continuous process requires continuous control. This requires automatic control which is on the job 60 sec. of every minute and not susceptible to distraction, as is an operator attempting to control a process manually. An instrument receives a signal and makes a correction, if required, in a predetermined manner and is not dependent upon human judgment. Even a simple recorder which makes a continuous record of a variable gives a record far superior to readings of an indicator noted by an operator on a log sheet, regardless of the frequency of his readings. Analytical instruments such as gas analyzers, pH meters, etc., perform tasks which cannot be done by an operator.

The operation of many continuous processes can be very hazardous unless properly controlled and protected by adequate safety devices. Instruments which actuate alarms and which may, in emergencies, automatically shut down a process contribute greatly to our ability to operate many hazardous processes with safety. We have in operation today in our plant at Niagara Falls, processes which would be next to impossible to run economically if it were not for adequate instrumentation. The first trend toward instrumentation was the conversion of old batch processes to continuous processes using as much of the old equipment as possible. The recorders and controllers were installed here and there in the process area where convenient. This type of installation gave way to a grouping of the instrumentation for a particular piece of operating equipment on one panel board. This enabled an operator to get a better picture of the over-all operating condition of that piece of equipment at any time with a minimum of walking.

The next step was to centralize the instrumentation for a complete process in a control room. This still further reduced the man-power requirements to operate a process, but it brought new problems. Time lags in the instrumentation increased, and installations of long runs of capillary tubing and instrument lines with process materials in them led to many difficulties.

With the advent of the modern transmitters, receivers "blind" controllers, graphic panels, etc., we have centralized control rooms manned by a few men who can operate large

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plants with maximum safety and productivity. Another result of this type of plant operation is the fact that much less time is required to train a competent operator. He no longer is required to spend many months or years learning the "art" of running a process.

These advancements in instrumentation have certainly contributed to the great increases in the productivity of industry in this country. The instrument manufacturers who have supplied the best in automatic control devices, analytical instruments, and safety devices have helped to produce more products and make possible commercial production of the many new products.

As an example, we in Du Pont have made substantial increases in the last 13 years in the production capacity of a number of products. Some of the more outstanding of these and their per cent increase between 1940 and 1950 are: (1) nylon—2700%, (2) neoprene synthetic rubber—1000%, and (3) ethylene glycol antifreeze—180%. We have also introduced many new products such as: titanium metal, polyethylene plastic, "Teflon" tetrafluorethylene resin, and the new synthetic textile fibers, "Orlon" acrylic fiber and "Dacron" polyester fiber.

In the 5-yr. period from 1946 through 1950, Du Pont spent approximately $550,000,000 in a program of plant expansion and improvement that included the construction of nine entirely new plants. The instrument investment in some of the facilities built with this money ran from 5 to 10% of the total specific investment, and is a very substantial portion of the total expenditure.

I have used Du Pont to illustrate this point only because I am most familiar with it and have the data readily available, but I am sure that a similar story could be told of many of the companies you men here represent.

The next question is, "When does additional instrumentation on a specific unit or process become uneconomical?" There must be a break-point. All of us at one time or another have heard the term "overinstrumented." "Over-instrumentation," which to us means that minimum cost production could have been attained with the installation of fewer or less expensive instruments, should not be tolerated. Enough instrumentation to achieve good economic return is all that can be justified. However, in the desire to curtail instrument investment to a workable minimum, we must guard against going too far.

We must have sound reasons for our instrument selection. There are many factors that should be considered in selecting the instruments and controls required for any specific process. They are: accuracy required, how essential is continuity of operation, what are the results of deviations from the normal operating conditions, how controllable is the process, corrosion resistance requirements both in the process and the surrounding atmosphere, etc. As an example of these considerations, take the case of the temperature control of a simple steam-heated hot water supply for a plant's locker rooms versus the temperature control of a paper stock continuous bleaching process, paper drying, or a chemical distillation process.

The accuracy required in the case of the hot water supply is certainly not great as the only requirement is that the water be hot enough for the individual to mix it with cold water to obtain a comfortably warm mixture with which to wash. The other factors, such as deviation from normal operating conditions, are not critical within rather wide limits; corrosion resistance is not a serious problem since only water and steam are being handled; continuity of operation is not very essential in that it can be shut down for maintenance between shift changes without causing much handicap. In short, this system requires only a reasonably well-built, simple thermostat type of temperature control.

In the case of the paper stock bleaching, paper drying, or chemical distillation process, however, an entirely different sort of problem exists. The temperature at various places in the process may have to be held constant with an accuracy of 1 to 2% continuously in order to produce a uniform quality product. The value of the raw materials and finished product may be high and even a short period of "off-control" operation may result in a loss of thousands of dollars. It is also possible that a definite hazard to personnel and equipment might be created if the temperature were allowed to deviate materially from the normal control point. Shutdown time for maintenance may be very limited and unscheduled shutdowns due to instrument failure may be very costly. The process material and the atmosphere in the process building may be very corrosive. The question of controllability should be carefully studied on such a problem. If the temperature starts to deviate from that desired, what must be done to correct it? How fast can a change be made? What are the time lags in the system? To sum up, this problem is one that will in general require accurate, very well-built measurement and control equipment. This is a much more expensive system of control than that on the hot water supply, but it can be economically justified.

The large investment in instruments today, plus the need for proper selection, installation, and maintenance of these instruments has created a serious problem for management. Adequately trained instrument engineers, foremen, and mechanics are not readily available in the open market. In fact, it has become almost axiomatic that you must train your own. To some extent we have been assisted in this training by the instrument manufacturer. Many have supplied organized training courses for mechanics and engineers. Others have provided training on specific request following the purchase of their equipment. Today, some of the instrument companies are sponsoring conferences for the experienced instrument engineer to further his knowledge in the field of instrument application to special problems.

Let us look briefly at the organization of a plant instrument group. Generally speaking, it is headed by an instrument engineer or supervisor who usually is technically trained and possesses considerable process "know-how." This engineer may report to the plant production section or the plant engineering section. In our own case, we believe the plant engineering section can do the best job of furnishing administrative guidance.

The instrument engineer must have supervisory ability. He is the key man in the instrumentation program and usually must be trained in the plant. This training is expensive, but offers attractive returns. Reporting to the instrument engineer or supervisor are one or more instrument foremen. Depending on the size of the plant and its instrument investment, this may vary considerably. In a large plant with many instruments, there may be a need for a much larger staff of instrument engineers and foremen.

We have, at Niagara Falls, an instrument supervisor with a staff consisting of an experienced instrument engineer, a junior engineer, three foremen and two assistant foremen, plus about 40 mechanics. The plant instrument investment which this group services is approximately $2,000,000 and consists of about 4000 units.

The instrument foreman must, of course, have supervisory ability. He should be practical in his approach, and some technical training is very desirable. He should have a comprehensive understanding of basic industrial instruments.

Reporting to the various instrument foremen are instrument mechanics, say, in the order of one mechanic for each 60 to 120 instrument units, depending on the type and complexity of those to be serviced. The number of men reporting to any individual foreman should be limited to 15 as he must be able to adequately check their work and the instruments they service.

There may also be a need for some "specialists" in this group of instrument mechanics. In our plant we have some

mechanics who specialize in electronic and optical instruments, others on scales including laboratory balances, and others on safety valves. There is sufficient work in each of these fields to keep at least two men busy full time. This of course must be determined in every plant according to the type and amount of equipment which must be serviced.

Another problem which must be solved is the application of a proper preventive maintenance program for instruments and controls. In most cases, this has been done for standard mechanical and electrical equipment, but not for instruments and controls. There is very little published experience in this field and, as with other plant equipment, the needs vary considerably based on the individual plant operating conditions and process materials. The keeping of adequate records on maintenance experience and costs will assist in the development of a proper program and, when established, it must be integrated with existing plant maintenance and production schedules. Such a program will result in less production down time, lower maintenance man power requirements, and a generally more economical operation, than a "catch-as-catch-can" or a "run-'em till they bust" method.

There may also be a need for instrument personnel in addition to the plant group depending on the size and type of company. They would be instrument design engineers to insure the proper application of controls and measurement equipment, and a technical or research group to handle difficult instrumentation problems where commercially available equipment does not quite fill the need for special applications. This group would investigate such problems and either develop or modify instruments to accomplish the desired results.

We have, in addition to the plant instrument groups, a departmental instrument design engineer and a research instrument group who supply service to all the plants and research laboratories of the Electrochemicals Department. The company's Engineering Department also maintains groups of instrument design engineers, consultants, and research personnel to assist all the operating departments in the handling of instrument problems.

Most of these instrument groups and services have been established since 1940 and have gone hand-in-hand with the increased application of instrumentation. The type of instrument organization and personnel requirements vary with the type and size of the industry involved, but with the increased application of instrumentation the need for an adequate staff of trained personnel should not be overlooked. Such a procedure will invariably lead to trouble as untrained and inexperienced personnel cannot properly design or maintain the modern instruments available today.

In conclusion, let me say that management in most modern industrial concerns has come to recognize instrumentation as a vital part of their plant equipment. It is an important as any other piece of equipment, such as motors, pumps, heaters, digesters, reactors, etc., and is not just an incidental extra. Its uses are rapidly expanding and offer excellent returns in safety, quality, efficiency, and production.

Management also recognizes that it must develop the necessary personnel to insure that the instrumentation investment is wisely made and maintained in a reliable manner with a minimum outage.

Q. On what portion of the labor force do you draw for your instrument mechanics?

A. At our plant we give men who want it an opportunity to train in our instrument department when job openings appear, if they have the minimum aptitude and experience required. This does not exclude any employee wherever he may work. We have not been successful in recruiting experienced instrument mechanics outside of the plant.

Q. What general group provides the best source of men?

A. Since 80% of our instruments are nonelectrical, men with good mechanical aptitude, regardless of what they formerly did, can be good instrument mechanics. Operators from the research semiworks with good mechanical aptitude have made good instrument mechanics since they are familiar with process control.

The Instrument Manufacturer's Problems in Meeting the Demands of the Papermaking and Converting Industries

H. O. EHRISMAN

It is a reasonably safe bet that instrument manufacturers would agree their biggest and most persistent problem is that there are never enough instrument purchase orders. It is equally likely that paper manufacturers have exactly the same problem with respect to paper products purchase orders. So, to that extent, we are all in the same boat.

Especially in recent years, all branches of industry have taken part in the phenomenal growth in the use of industrial instrumentation. Quite naturally the paper industry asks whether it is keeping abreast of other industries in the use of these tools for efficient processing.

It is difficult to make such comparisons between different industries because their processes are so different, but comparisons are interesting even though they do not provide positive conclusions. With that viewpoint, let us compare some statistics on instrument use among industries which may be of special interest.

In every industry there is a relationship between instrument purchases and the total investment in new plants and equipment; and when making comparisons, the relative sizes of the different industries must be taken into consideration. We have selected the chemical, petroleum refining, and textile industries for comparison with the paper industry.

If we compare the total dollar volume of instrument purchases per million dollars spent on new plant and equipment by each industry, we have a figure which is independent of the comparative size of those industries. Thus, by taking an average over the past 4 years, we find that for every $100 spent on instrumentation by the paper industry, the chemical industry spent $86, the textile industry $65, and the refining industry $56, all based on equal investments in new plant and equipment.

Those figures may seem startling because it's the total dollars invested in instrumentation by an industry that makes the big noise. Accordingly, if we ignore the size of the industry and compare only total investment in instrumentation by industry we get very different figures. Again, taking an average over the past 4 years, we find that for every $100 spent by the paper industry, the chemical industry spent $570, the textile industry $87, and the refining industry $289.

Actually, such comparisons are of secondary importance. The question which comes first is this: to what extent is a given manufacturing process affected by physical variables, and to what extent are those variables being measured and controlled by up-to-date instrumentation?

If we compare individual mills in the paper industry we find, as you all know, very substantial differences in the amount of instrumentation used on processes which otherwise are essentially the same. And that's important. It emphasizes that there are wonderful opportunities for improvement through instrumentation throughout the paper industry, just waiting for the right combination of men to do something about them.

An indication of growth in the use of instrumentation in the paper industry may be gained by contrasting two sulphate pulp mills of similar size, designed to make a pulp of comparable quality. The first mill, built in 1938, about 15 years ago,

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spent $70,000 for instruments, measuring elements, primary devices, and control valves. The second mill, one of the newest in the industry, spent over $300,000 for instrumentation. Part of the difference can, of course, be explained by inflation. The big difference, however, is due to greater recognition of the benefits to be gained, hence expanded use of instrumentation. It is noteworthy that over the past 15 years the first mill mentioned has been a steady buyer of additional instrumentation, emphasizing the recognition of not having gone far enough originally when the mill was built.

It should, therefore, be repeated that in the final analysis, our real interest is not in how much instrumentation is used, but rather how effectively the physical process variables of the complex papermaking processes are being controlled through instrumentation.

Accordingly, one of the first things to emphasize is that process control instrumentation can be no better than are the capabilities of the instrument personnel who engineer its selection and supervise its operation and maintenance.

The importance of capable instrument engineering cannot be overemphasized but, unfortunately, many mills still cannot boast of having a qualified instrument engineer on the staff! In fact some mills still cannot even claim to have a qualified instrument mechanic.

Sometimes there are perfectly good reasons for such a situation, and such situations are not necessarily peculiar to the paper industry. For example, the operations of a mill may be too small to justify specialized instrument personnel. Sometimes though, it is because mill management has not yet become fully educated to the golden opportunities available through instrumentation.

Whatever the reasons may be, they present the instrument manufacturer with one of his selling problems. His sales personnel must not only be familiar with the technical aspects of his increasingly numerous different instrument products but, more important, they must have a working knowledge of industrial processes, processing equipment, and the instrument application considerations essential for best results. In short, the instrument manufacturer's sales organization must be made up of highly specialized engineering personnel so that customers may have expert assistance to develop the widest and most effective use of instrumentation.

What this means may be illustrated by an example. The company I represent adopted the policy, long ago, of hiring as sales engineers, only chemical, mechanical, or electrical engineering graduates from colleges of recognized scholastic standing. This gives the needed insurance of starting with a man who has a basic understanding of engineering fundamentals. As might be expected, preference is shown to those engineers with experience in a major process industry where they have had the opportunity to gain familiarity with processing equipment and production and quality considerations. Such men are then given extensive training in our company training school, the factory, and on instrument installation and service work in customers' plants.

Note that all of these considerations emphasize the technical ability of the man, rather than salesmanship, which is in sharp contrast to the requirements of most sales organizations. Following the same reasoning, our sales engineer is paid on a straight salary basis which takes the emphasis off how much he sells and puts it on how satisfactorily he meets customer's instrument requirements.

Obviously, the sales engineer cannot become an expert in all the different processes employed in the many industrial plants in his sales area. His work must, therefore, be assisted by a staff of home office engineers who are instrument specialists for the various industrial fields. These specialists are members of their industries' trade associations. They closely follow their industries' technical developments and, finally, because their work with the local sales engineers frequently takes them into customers' plants, throughout the industry, they possess an unmatched accumulation of knowledge and experience in process control problems of the industries in which they are individually specialists. For example, our paper industry specialists not only know the many potential instrument applications in the industry, but what's more important, they generally have a good understanding of the different processes, the related equipment and machinery, and a sense of the relative importance of the physical variables of the processes to be controlled.

The quality of the sales engineer's training is a point which cannot be overemphasized. When a customer buys instrumentation he gets equipment, and with it he gets knowledge, experience, and engineering service. If that service enables him to employ the equipment to full advantage, the results are happy from every viewpoint; but if the service is faulty, through the engineer's lack of experience and knowledge, even a top-quality instrument may be incorrectly applied—with results that are sure to be disappointing and may even be costly.

These remarks, intended to explain the special training and characteristics of a sales engineer, do not apply to any any one particular company. All of the principal instrument manufacturers employ sales methods and personnel which are comparable.

The need for specialized engineering sales personnel, combined with the sales engineer's inability to average more than two or three completed sales calls per day, results in personal selling of an unusually expensive type. Sales managers in all fields of marketing closely watch the average cost per sales call. This is usually arrived at by dividing total selling expense during the year by the number of sales calls made. The answer is always a surprisingly big figure; but the instrument manufacturer finds his to be among the very highest. In some companies it averages over $50 per sales call. Accordingly, every effort is made to keep the frequency of calls on a given plant reasonably proportioned to that plant's real or potential instrument needs.

Sales costs per call vary widely between one plant and another, depending to a large extent on their respective self-sufficiency in instrument engineering and maintenance. At one extreme are those plants that find it desirable to accept detailed help from the instrument sales engineer every step of the way from the inception to the completion of a new control system. At the other extreme are those plants which, within their own organization determine the detailed specifications of exactly what they want and ask only for a price and delivery quotation.

A word on prices may be in order here. Many of you already know it, but it is worthy of mention that the instrument industry is very competitive, pricewise. Top-quality instruments of comparable types, as offered by the leading instrument manufacturers, only rarely show an important price difference. Where the price difference is more than 1% or so, it almost certainly is due to differences in the quality details of the instrument in question, or whether certain accessories were included in the quotation. Control valves, for operation with controlling instruments, show somewhat wider price differences because they are available over a relatively wider quality range. In the final analysis, the buyer gets pretty much what he pays for.

While on the subject of price, it is worth mentioning that a concession in quality, because of an apparent price advantage, is not as big a bargain as it may appear to be, due to the existing corporate tax structure. If, for example, you are in the 82% tax bracket, then each such dollar of apparent savings will in fact really net only an 18¢ saving! Even if the excess profit tax should be repealed, the remaining normal tax and surtax would still limit real savings to no better than 48¢ on the dollar, which would seldom justify compromising an instrument purchase at the expense of quality.

Quality is always an important buying consideration, but is

especially important when buying instrumentation. On some applications, particularly on a continuous high-production process, a fractional percentage gained in accuracy may permit substantially greater savings and benefits. Good instrumentation can keep a process running at maximum efficiency; but faulty instruments can cause a process shutdown. With present-day high overhead costs, when shutdowns can quickly run into many hundreds of dollars an hour, maximum instrument accuracy and reliability are more important than ever.

From time to time every manufacturer has delivery problems, and the instrument manufacturer is no exception. Because instrumentation must be engineered to the process and its equipment, instrument specifications can rarely be established before the process equipment details are all settled. Instruments, therefore, become a tail-end consideration. Sometimes, however, special alloys are required to resist the corrosiveness of the application. Special alloys frequently involve relatively long deliveries, especially where castings are necessary, as may be the case with Venturi tubes and control values. Insofar as possible, such items should be ordered well in advance of the rest of the instrumentation so as to be available when needed.

Copies of installation and maintenance instructions go with every instrument shipped, together with certified dimension prints, special drawings, etc. Instrument manufacturers have an essentially foolproof system to insure sending the appropriate material with each shipment. However, despite all precautions, there are occasional complaints that the material was never received. Perhaps it gets lost in the mill's receiving room; whatever happens to lost material is hard to establish. Of course, it incurs wasteful duplication of material and effort, but what is more serious, the installation instructions are not available when most needed.

After installing his new instrument, the customer has a right to expect that it will work. Occasionally, it doesn't, and then the manufacturer's sales engineer gets an emergency call for first aid. The sales engineer generally drops whatever he is working on, changes his itinerary, and travels the necessary distance to the mill in question where, more often than not, he finds the trouble is not with the instrument, but with some detail of the associated equipment. In a recent case, a sales engineer was obliged to make a special trip involving over 200 miles of travel because the measuring system of a newly installed temperature controller was claimed to be inoperative. What the sales engineer found was that there was no steam going to the process, because an overlooked block valve, closed during installation, had not been reopened.

Such experiences are not uncommon, and they lead us to an important point. When an instrument appears to operate improperly, the chances are very good that the trouble is not in the instrument but rather somewhere in the associated equipment, and of such a nature as to be beyond the ability of the instrument to do anything about it.

For example, the most common cause of trouble with consistency controllers results from an interrupted supply of dilution water. The instrument can only open the dilution water valve to its maximum capacity, but unless sufficient water is available in back of the valve, control is obviously impossible. Similarly, if stock reaching the consistency regulator is too thin, the controller can do no more than shut off the dilution water. It obviously cannot dewater the stock.

For another example we might consider flowmeters which, as you know, are dependent for their measurement on a primary device, such as an orifice plate, installed in the pipe line. If, however, tramp iron or other foreign material becomes lodged in the pipe ahead of the primary device, or because of erosion or corrosion the inside wall of the pipe is pitted or unusually rough, then the accuracy of the flow measurement may be seriously affected. Here again the trouble rests not in the instrument but in the associated process equipment.

Let's look at one more example, namely, sheet moisture control on a paper machine drier, where again, in the majority of cases the source of the trouble is found elsewhere than in the instrument. It may be in a faulty drier drainage system with improper condensate and air removal from the individual drier rolls or any one of many other paper machine conditions. Uniform sheet moisture control under such circumstances may simply be impossible. The instrument will record the variations, but due to the heat transfer lags in the drier rolls, the controller is helpless in gaining control. In such cases, the controller might even overcontrol and actually make the variations worse. Should that happen, the operator might then conclude that the controller itself is at fault, and shut it off. There have been such cases, and even one where use of the controller was permanently abandoned for just that reason.

This application offers a striking example because, as you all know, paper machine drying involves a great many physical variables, all of which influence final sheet moisture content. The long list of such variables would include wet drier felts, tension changes of the drier felts, poor drier roll ventilation, speed changes, changeable nip pressure on press rolls, plugged wet felts, stock freeness and consistency variations, wet-end vacuum variations, stock head variations in back of the slice, etc. and any one of these variables, or still others, might act up and create a condition beyond the ability of any moisture controller to perform its functions.

An instrument never forgets, never strays from the job, never goes to sleep, and will be on the job day in and day out, turning in a perfect performance each and every day; but an instrument cannot think! It will perform truly amazing functions but is, nevertheless, dependent upon supervision by the operator who must exercise the necessary thought when unusual situations develop.

Let's go back again to our paper machine example because it serves equally well to make one other point, namely, how instrumentation should be selected and applied to contribute its beneficial capabilities on a unit process, whatever the process may be. There is no mystery involved—the answer is simple. The only requirement is to study the process from start to finish, identifying all the physical variables which could affect the product in moving through the process, determining those that have an important effect on the product, and applying control to each and every one of them. Secondary variables, having only a minor effect on the product, may be merely measured, using simple indicators or recorders, for the purpose of assembling all pertinent process intelligence on the centralized instrument control panel. However, primary variables should always be controlled to insure that the process will be completely free from periodic upsets by overriding uncontrolled process variables. If that is done, then processing and product will be uniform.

It must be apparent that only limited results are possible from the application of an instrument at the tail end of a process, in the hope that it will serve as a miraculous cure-all, correcting all upsets of process variables preceding it! Yet, that is a very common pitfall and may lead to wrong conclusions about the value of instrumentation. It helps explain why, when only a single instrument is applied to the end of a process, such as a moisture controller at the end of a paper machine, and results subsequently fall short of expectations, that the instrument is sometimes turned off permanently, the mill goes back on hand control, and loses confidence in all instrumentation.

If one instrument, at the end of a complicated process, could be an over-all cure-all, it would provide a very cheap solution to all the problems within the process! If, for example, it worked in the case of a paper machine, it would perhaps eliminate the cost of a new drier roll drainage system, a better paper machine speed control system, a new wet-end vacuum system, etc.; but, unfortunately, things rarely work that way.

Generally, the cure-all can only be found by instrumentizing all the important variables in the process.

Some of you may be thinking that instrumentation applied to all of the variables in the process is very expensive. A complete instrument control system might cost a lot and still be far from expensive! The cost of completely instrumentizing a process varies widely, depending directly on the number and type of physical variables it is necessary to control. However, compared with the total cost of the plant and equipment which make up the process, instrumentation usually runs from less than $^1/_2$ of 1% to as much as 8%, an uncommon maximum figure.

But that is only part of the answer to your fears. The rest of the answer is even more important. The more instruments needed on the process, the more good will instruments do for the process, and the greater will be the benefits to the mill. Instruments generally pay for themselves faster than almost any other type of process equipment—sometimes in only a few weeks. They unquestionably contribute enormously in helping the paper mill to deliver products of the exact quality demanded by its customers. Instruments importantly increase production; they substantially reduce waste of raw material and always make the processing operations much less dependent on human skill and human toil and sweat. The advantages are many, depending upon the unit process in question.

The instrument manufacturer's everyday problems in meeting the demands of the paper industry are really no different from those he encounters in serving other industries. The differences between one industry's requirements and those of another are essentially technical, depending on the processes involved and the equipment.

The fundamental problem, which underlies all his efforts to serve all his customers, is a problem of education. When all industries realize—as the instrument manufacturer thinks they should—that modern instrument engineering means operating efficiency and operating profits, and that quality in instrumentation is exactly as important as in any other equipment or service—the instrument manufacturer will have no problems worth mentioning.

Instrumentation Used in Other Industries Which Might Be Applied to Paper Manufacturing

JOHN R. GREEN

In order to present ideas and methods from one industry to another, there must be some similarity in the processes employed, if value is to be gained by the receiver. As an example, engineers from the glass industry frequently attend the technical meetings of open hearth operators. Both industries operate high-temperature melting and refining furnaces, although the furnace design and methods of operation are quite different.

A description of measurement and control systems as applied to open hearths, soaking pits, and reheating furnaces in the steel industry might be novel to papermakers, but hardly applicable to their daily work.

In an attempt to provide some potentially useful material for the paper industry, two approaches will be used.

The first consists of a brief review covering some of the presently available industrial instruments and control systems which are applicable to the processes met in the beneficiation of minerals. This portion will be an abstraction of a paper delivered last year for the American Institute of Mining and Metallurgical Engineers. Some similarities exist in the methods and processes employed to convert raw materials into forms suitable for the manufacture of finished products.

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H. O. Ehrisman, The Foxboro Co.

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In the mineral beneficiation industry, indicating, recording, and control equipment is available, though not always in general use, which ordinarily meets the requirements for measurement and automatic control of the process variables. Many of these controls are the familiar industrial instruments which have proved themselves for many years in plants of all descriptions. Others are adaptations of the familiar types, modified to meet the peculiar requirements of the industry. Still others are entirely new types, in whole or in part, developed to meet specific problems which have appeared in the research phases of beneficiation and concentration.

MATERIALS HANDLING

Perhaps the simplest way to present the available instruments is to run through the common processes involved in beneficiation or concentration of an ore and briefly point out the instrumentation available and the principles involved.

The first phase of mineral beneficiation ordinarily utilizing instrumentation is the handling of raw materials, that is, weighing, blending, and conveying.

Several different principles of weighing have been successfully adapted to automatic control. A general type of continuous conveyor scale (Fig. 1) is comprised of an endless conveyor belt or gravity feed supported by two pulleys. This section of the conveyor is in turn suspended from overhead scale levers.

The first method of recording and integrating the weight of material passing over the conveyor utilizes a motion transmitter, a device consisting of an armature suspended from the scale beam and extending into transmitting inductance coils. By linking the receiving armature to a recording pen, a continuous record of all positions of the scale beam is obtained. The addition of an integrating mechanism provides a method of totalizing the weight of material being conveyed in any given period of time. Automatic means are provided to pre-

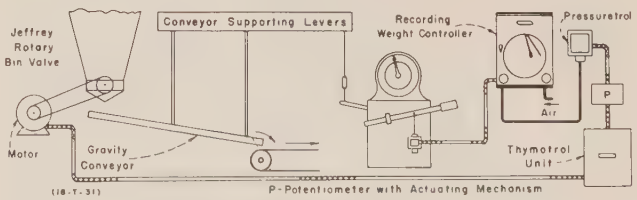

Fig. 1. Continuous weighing

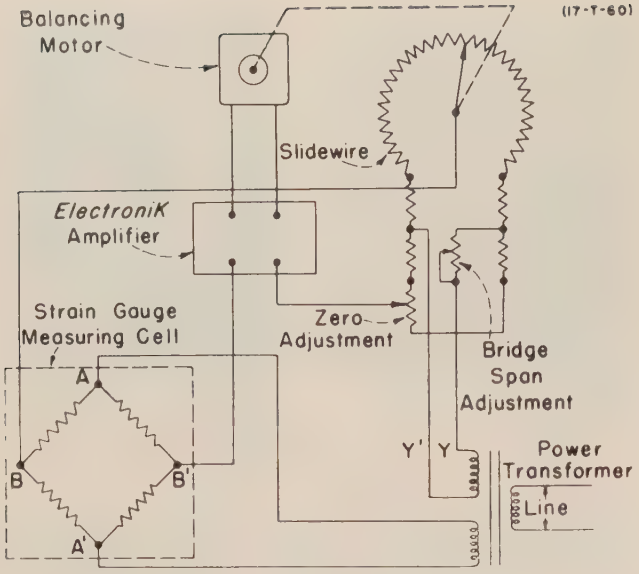

Fig. 2. Strain gage circuit

vent false total reading caused by conveyor stoppage. Either electric or electronic forms of recorders, controllers, and totalizers may be used.

The second method of recording and integrating weights uses some type of load cell or strain gage. One type is shown schematically in Fig. 2. An electronic a.c. bridge potentiometer continuously evaluates the condition of the a.c. bridge by balancing a known portion of the voltage against the unknown portion. The addition of an integrator provides a means of recording the total weight of material conveyed, while manual zero and span controls permit canceling out tare weights, such as that of the unloaded conveyor.

A third method of measuring, recording, and controlling tonnage or weight involves the use of a thermal converter which is a device to measure the motor load of the conveyor. The output of the thermal converter is amplified and recorded on an electronic potentiometer.

All of the above systems have been utilized for automatic control, and are available with both on-off and proportioning action, either electric or pneumatic, to operate vibratory feeders and motor speed control units for rotary bin valves, star feeders, rotary disk feeders, variable speed conveyors, etc. Systems are available which will accurately proportion two or more materials to form a proper blend or mixture for further processing.

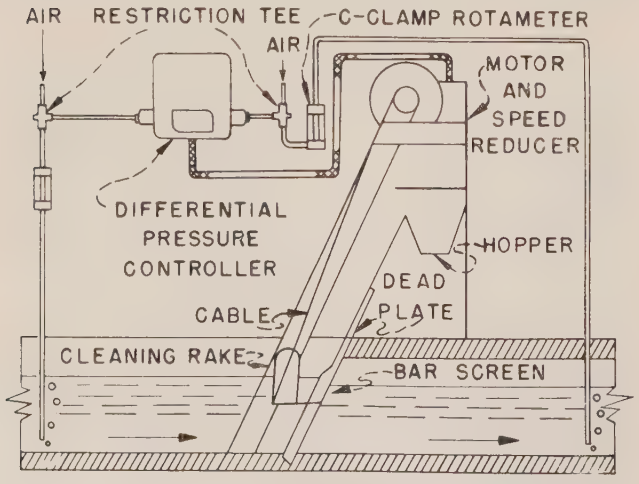

Fig. 3. Bar screen cleaning rake control system

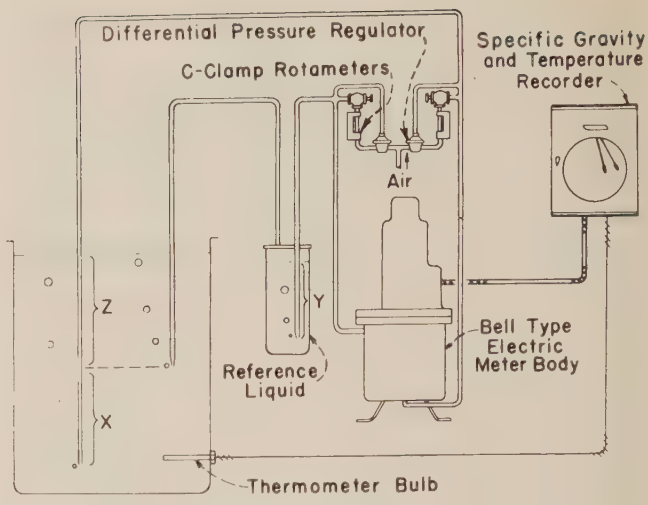

Fig. 4. Density control—bubbler type

Speed Measurement

An important factor in materials handling is the operating speed of the handling equipment which must be integrated with weight control to maintain required tonnage throughput. Speed of rotation of rotary kilns and driers must also be integrated with feed rate.

Speed measurement and control of conveyor belts, conveyor screws, rotary kilns and driers, and other types of equipment are usually effected through a tachometer generator transmitting to an indicator or recording controller of the electronic potentiometer type. The controller, in turn, actuates a variable speed motor or other type of speed control device. Systems for varying speed automatically in accordance with one of the other process variables are available as, for instance, weight on a conveyor belt.

Screen Cleaning

Where bar screen or traveling screen devices are utilized, automatic control of cleaning rake operation or traveling screen is effected by measuring the differential across the screen as shown in Fig. 3. An increase in the differential pressure actuates a switch in a differential pressure controller, causing the cleaning rake or traveling screen to operate. When the screen becomes clear, the differential pressure will drop and the differential controller will stop the mechanism.

DENSITY, LEVEL, pH, AND TEMPERATURE MEASUREMENT

Instrumentation for classifiers, flotation cells, separators, and similar devices where a pulp is involved usually consists of

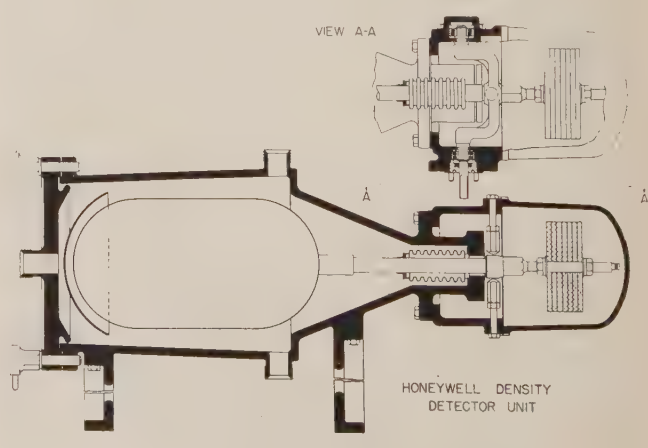

Fig. 5. Density detector—displacer type

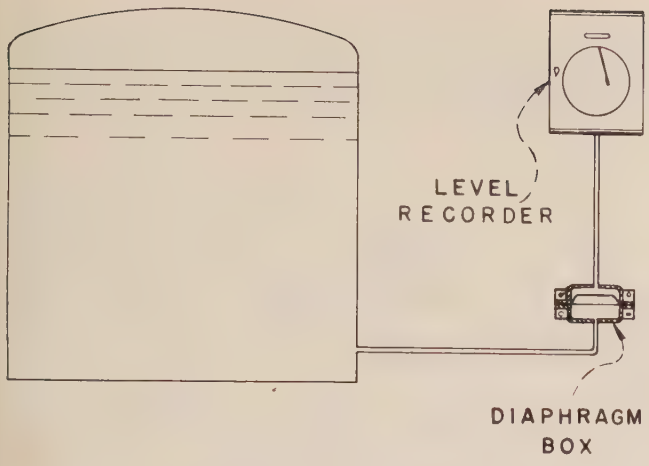

Fig. 6. Digester level measurement

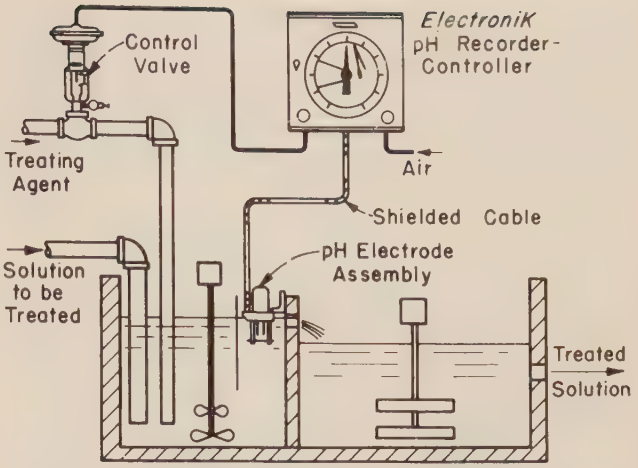

Fig. 8. pH control with immersion-type electrodes

measurement and control of pulp density, liquid level, pH, and temperature.

Density

Measurement and control of pulp density has posed one of the most difficult problems in mineral beneficiation, due to the nature of the pulp and to the conditions, such as agitation, foaming, and sanding which often exist at the desirable points of measurement. Several usable methods have been employed, including use of a hydrometer float, and measuring back pressure developed in a bubble tube immersed in the pulp.

One method, as illustrated in Fig. 4, consists of two bubbler pipes with air purging through the two tubes at constant rates. The difference in back pressure is measured by a manometer which carries an armature riding in the transmitting coils of an inductance bridge. The receiving coils carry a receiving armature linked to a recording pen. The system is calibrated to read directly in terms of density. A variation of this device utilizes an electronic potentiometer in which the receiving armature is linked to the balancing motor. Both systems are applicable to control and may be used on light or heavy media systems. A means of back flushing the bubbler pipes is desirable, and is often linked to an electronic timing circuit so that flushing is accomplished automatically and periodically. Care must be taken in locating the tubes to prevent sanding.

A density control system, recently developed for the food industry for controlling the density of fruit juice concentrates, utilizes a principle that may prove applicable for pulp density control in the mineral field. This system, shown in Fig. 5, utilizes a transmitter which produces a pneumatic signal proportional to the density of the liquid passing through a sampling chamber, and a receiver which interprets the signal to indicate and record density and to produce appropriate control action when necessary. The transmitter consists of a submerged displacer in a sampling chamber, and a pneumatic-balance unit which exerts pressure to keep the displacer in its proper position.

The totally submerged displacer is buoyed up by a force that is equal to the weight of the fluid it displaces. Since the displaced volume remains constant, the buoyant force is entirely dependent on the density of the displaced fluid.

Most liquid level measurements are basically pressure type systems. These are in two principal forms: those employing a pressure gage as the measuring instrument, and those in

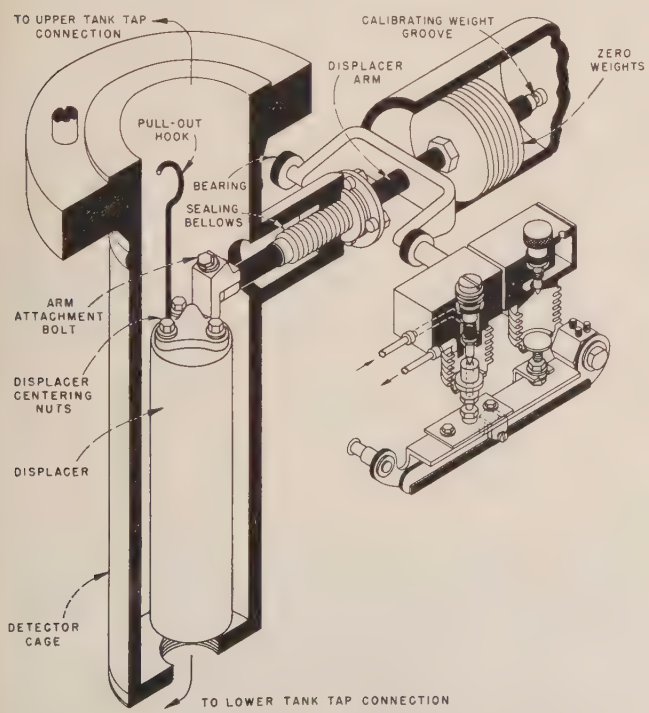

Fig. 7. Level detector—displacer-type

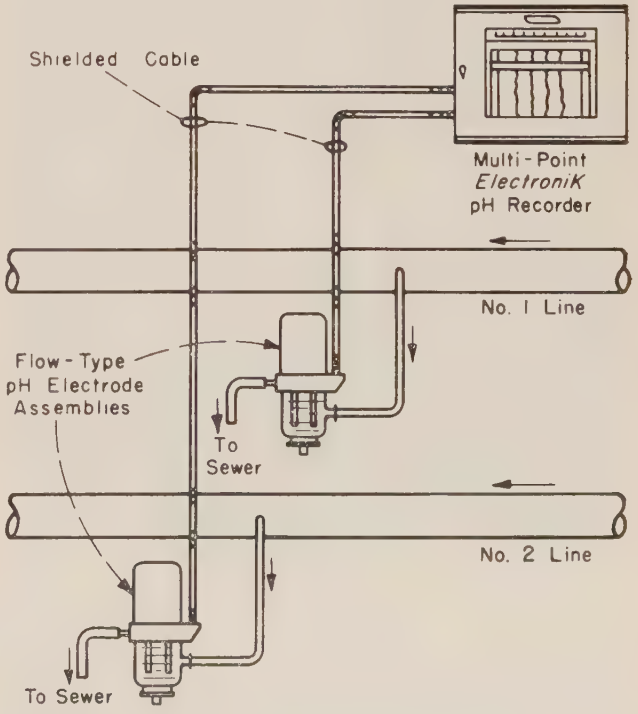

Fig. 9. pH control with flow-type electrodes

which the conventional manometer or U-tube construction common to flowmeters is employed. There are three major types of pressure gage systems: (1) the basic system where pressure of the liquid head is directly imposed in the actuating element of the pressure gage; (2) the diaphragm box system, wherein a flexible diaphragm is interposed in the pressure

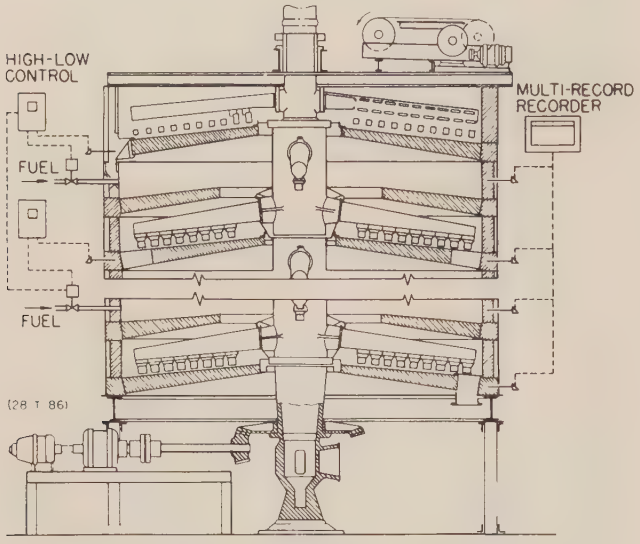

Fig. 10. Multiple hearth furnace

measuring system; and (3) the purge or bubbler system wherein the back pressure of the purging medium is a measure of the liquid level. Figure 6 shows a typical diaphragm box installation. The box is sometimes located inside the vessel. The bubble tube method, described in some detail for the measurement and control of density, is the method most used where entrained solids, etc., are present.

pH

Measurement and control of pH, the hydrogen ion concentration, is frequently quite important, as both the per cent recovery and the grade of the recovered mineral are dependent

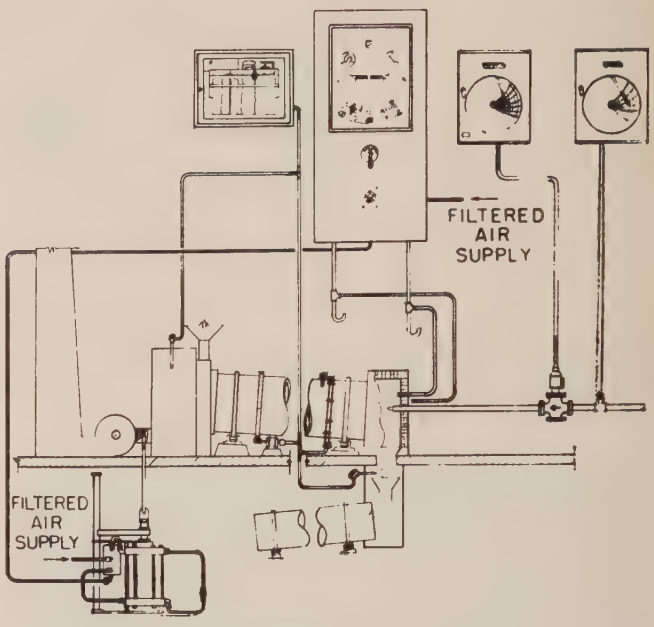

Fig. 11. Rotary kiln control

on this factor. Various types of electrode assemblies of both the immersion type (placed in the tank or cell) shown in Fig. 8 and the flow type (installed in a flow line) shown in Fig. 9 are available. The output from these assemblies is measured

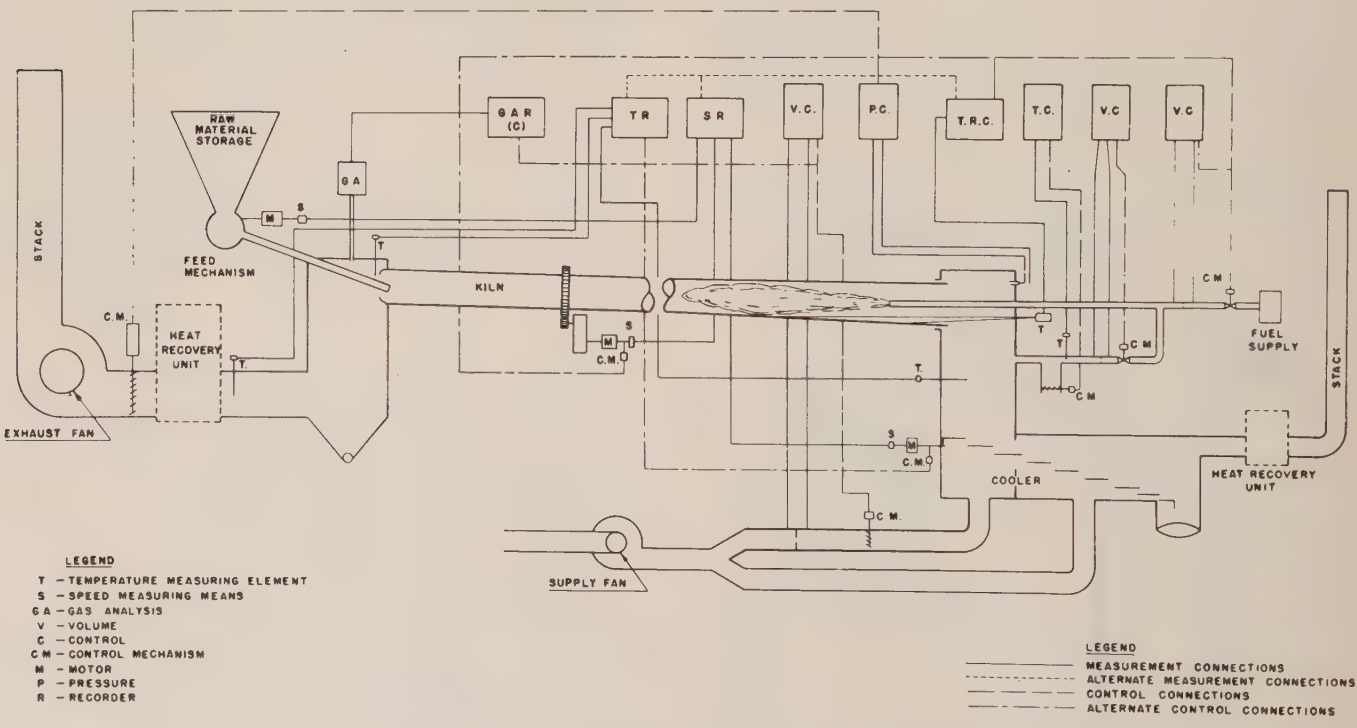

Fig. 12. Rotary kiln schematic layout measurement and control applications

A system using a displacer buoyed up by the liquid, very similar to the displacer method of density measurement and control, is also available. Figure 7 shows the measuring and transmitting section of this system.

and recorded by an electronic potentiometer. Control mechanisms, either electric or pneumatic, actuate valves or dry feeders controlling the addition of reagent, and the pH content of the pulp or slurry can be very closely maintained.

PYROMETALLURGICAL INSTRUMENTATION

In the field of pyrometallurgical processing are found the multiple hearth and rotary kiln, for roasting, calcining, smelting, and drying. Over the years, specific instrumentation has been evolved for these operations, and application of this instrumentation to the mineral beneficiation field was a normal step.

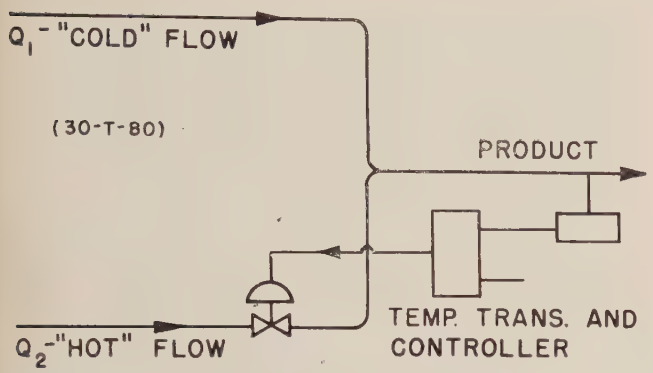

Fig. 13. Simple flow-bending "temperature" control system

Multiple Hearth Furnaces

Instrumentation for multiple hearth furnaces may vary from simple recording of temperatures at the various hearth levels, to automatic regulation of hearth (and product) temperatures. Frequently this is accomplished most effectively on these counterflow systems by interlocking the controls from each level to the next lower level. Figure 10 shows a typical multiple hearth furnace with interlocked hearth temperature controls, and also multiple recording of hearth temperatures. Draft controls may be applied to insure proper heat distribution throughout the furnace.

Rotary Kilns

Other fairly common operations in mineral beneficiation are agglomeration, calcining, drying, etc., in rotary furnaces, either kilns or driers. Here the instrumentation recommended has evolved over many years and has now reached the point where an almost standard package is available. Figure 11 shows simple instrumentation applied to practically all rotary kilns, while Fig. 12 illustrates a very complete measurement and control system.

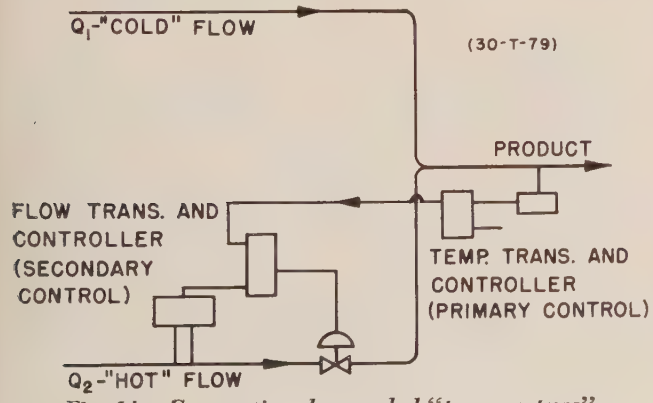

Fig. 14. Conventional cascaded "temperature"

Basically, the rotary furnace is a device for subjecting material to a given temperature or series of temperatures for given periods of time. The time-temperature relationship is mainly dependent on the speed of rotation of the kiln or drier, and the amount and distribution of heat supplied. The distribution is dependent, in great measure, on the pressure in the kiln. Factors involved in establishing the time-temperature relationship required are the process involved, whether calcining, drying, or agglomeration; the material being processed; and the characteristics of the final product desired.

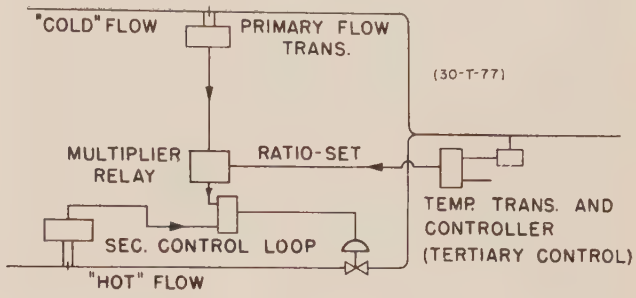

Fig. 15. "Hot" flow ratio—cascaded control system

Recommended instrumentation may include speed measurement (or control) through use of a tachometer generator and electronic potentiometer controller operating a speed control mechanism; lining temperature control through use of a radiation pyrometer sighted on the lining and an electronic potentiometer controlling fuel, or fuel-air ratio, to the burner; a product temperature recorder controller also utilizing the radiation pyrometer and acting to maintain product temperature at a desired value; and pressure control which affects temperature gradients in the kiln by operating a damper in the exhaust duct or stack. Volume, pressure, and temperature measurement and control for both primary and secondary air are commonly used supplementary instrumentation. Additional instruments are required on coal feeders to maintain proper supply and safe conditions. Occasionally, thermocouples, installed in the lining and connected to instru-

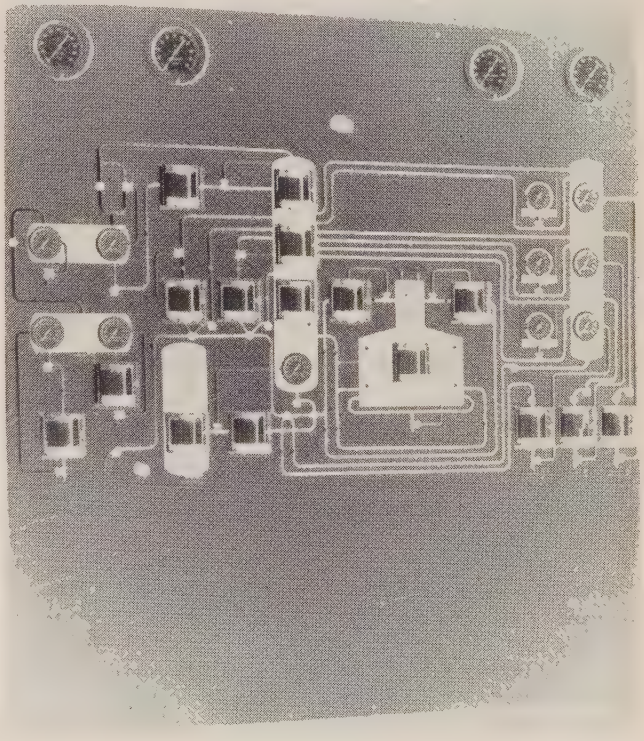

Fig. 16

ments through commutator rings, are used to check temperatures along the length of the kiln.

CONTROL-SYSTEM ENGINEERING

A second approach to increased efficiency of control as experienced in other industries can be found in the control principles being employed. Some extracts from a paper on "Modern Control-System Engineering" delivered last Fall before the Measurement and Control Conference held in Stockholm will serve to emphasize a few of these potentials.

The design and layout of processing equipment which permits simplicity and ease of automatic control and the ability based on the knowledge and experience required to select the least costly control method are two phases of advanced control economics which are far from being exhausted.

The ever increasing capacities or speeds and the extension of continuous process designs were made possible by regulation of all variables as well as placing additional demands upon the abilities of control systems.

As has been very properly stated—automatic controllers are increasing in their work, but incapable of reasoning. It is the function of the instrument and process engineers to provide that necessary reasoning power when they analyze the process, and then specify and install a system of measurement and control.

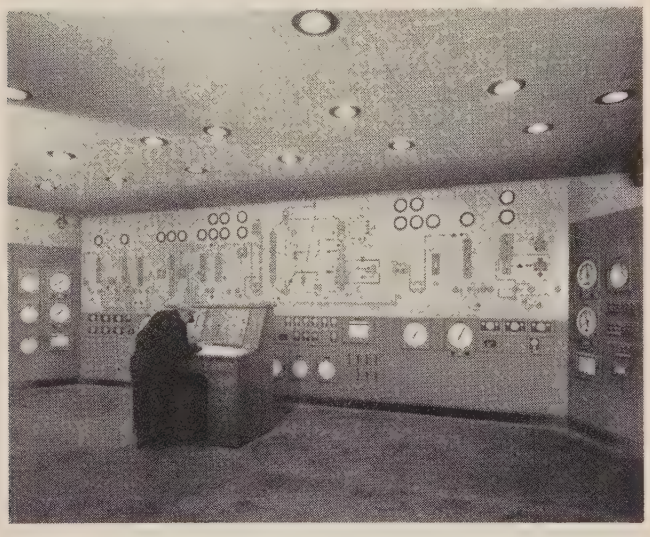

Fig. 17

CASCADE CONTROL SYSTEMS

A principle of control, which is being widely employed to improve product quality, is known as the interlocked or cascade system, sometimes referred to as "piggyback" control since one controller is riding on the "back" of another. As elementary illustrations of this principle, three schematic diagrams are shown.

Figure 13 shows a plain temperature control, making use of a single controller to regulate a product temperature which is effected by two flows. The second system, as illustrated in Fig. 14, has added another controller for the purpose of applying early corrections to variables in one flow, the required value of which is set automatically by the product temperature controller. A further refinement is shown in Fig. 15 where three control systems are cascaded so that one flow is continuously proportioned to a second with the proper ratio between the two being established by the final product temperature. Such methods are found to be extremely advantageous in high-speed processes having a number of variables, particularly when undergoing load changes or when starting up or shutting down the operation.

It can most emphatically be stated at this time that the advantages to be gained by properly interlocking two or more control systems far exceed the sum of improvements secured by their individual operation.

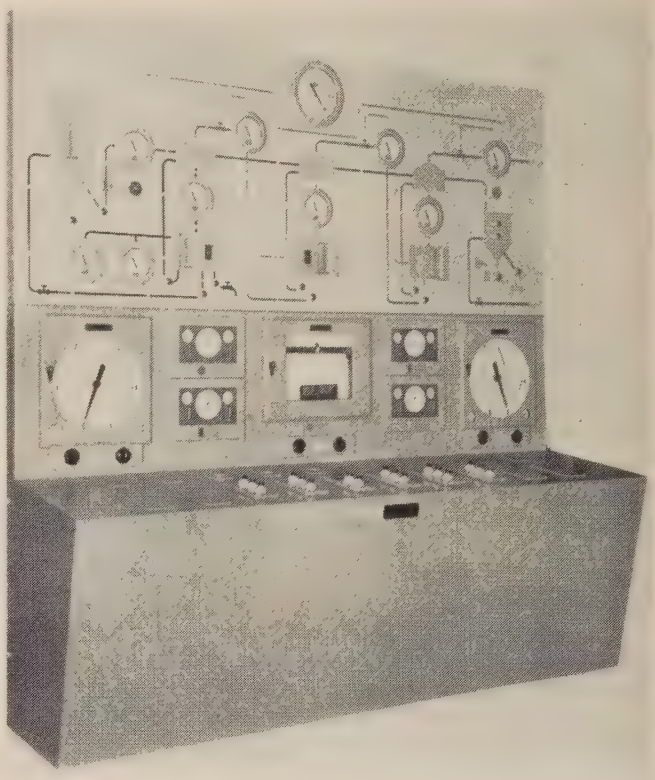

Fig. 18

Artificial-Automatic Control Action

A second approach to modifications of control systems used largely to increase production rates is found in what might be termed an artificial but automatic control action which is introduced into a control system by the occurrence of abnormal or cyclic external conditions.

The most simple example illustrating this principle is the widespread use of the so-called "limit controls," which may in themselves employ some of the stabilizing effects of cascaded control.

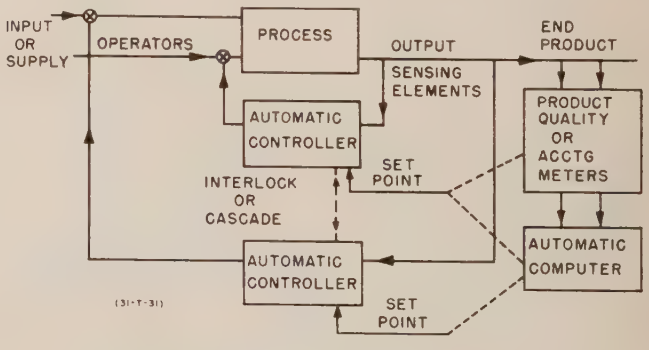

Fig. 19

The use of such control adjuncts automatically performs operations with greater speed, safety, simultaneous action, and precision, than could be secured by manual means. At the same time it enables the operator to better apply his skill and experience to the uncontrolled mechanical factors which have their bearing on the maximum production of a quality product.

GRAPHIC PANEL ENGINEERING

A third type of engineered control system is represented by what is commonly referred to as the "graphic panel." In this concept the process diagram, usually with distinctive colors and symbols, presents a related picture of the entire operation in a compact space.

The full graphic panel, as illustrated in Fig. 16, makes use of miniature instruments located in the process diagram itself for a majority if not all of the indicating, recording, and control functions.

The semigraphic panel, as illustrated in Fig. 17, may have some elementary instruments, signals, and identifying symbols in the complete panel diagram with related instruments of either miniature or standard designs grouped around the graphic presentation. This arrangement of a panel board is frequently used in order to retain the greatest accuracy, visibility, or comparisons which are secured from instruments of conventional design.

The instrument operating console, as shown in Fig. 18, may not use any graphic presentation but concentrates all operating measurements, automatic controls, and manual regulators for accessibility to the process operator.

The prime objective in every case is the conserving of man power, coupled with better and faster training of operators to apply skilled manipulation of complex processes.

CONTROL SYSTEMS OF THE FUTURE

Let us look at some of the potentials and problems of the much discussed "automatic factory."

Actually, there are a number of "near automatic" or "push button" factories in operation today with many more in the design and planning stage. At least one plant has its entire control system precisely syncronized and set from a single manual loading regulator.

In order to visualize a concept of what complete automatic operation can encompass, Fig. 19 illustrates schematically some of the principal components and their relationship to each other which may be required in an engineered control system which removes as many as possible of the human links from a process operation.

By comparison to the environmental method of securing the desired end results, which is used in most of the semiautomatic systems, a rapid and automatic analysis of the end product must be obtainable for fully automatic manufacturing.

As a result of a host of diverse equipment based upon spectroscopic, conductive, ultrasonic, titrative, and radiation or photoelectric principles, many such qualitative measurements are now being made in the fields of chemical composition, viscosity, density, appearance factors, moisture content, and other end-product properties.

Whenever one or more suitable end-product analyses are available, these measurements can occasionally be transmitted directly (as illustrated in Fig. 19) to re-establish the controlling environmental conditions.

More frequently the requirements call for more "brains" than such a direct sequence is able to accomplish. Into this field of operation, the rapid advances now being made in the design and availability of automatic computers open almost endless possibilities. Into such devices signals can be fed from any number of end-product measurements for digestion by the computer with resultant properly correlated commands to the environmental controllers. The proper selection of suitable means for intercommunications between such components is merely one of the necessary refinements required for the wide usage of such equipment.

The speed with which engineered control systems are applied in any industry is determined primarily by the economics of "earning their own keep." The tools, equipment, and methods are largely available or within sight.

The human requirements for perception of the problem by management, the skill in process and equipment layout by design engineers, and a substantial broadening of experience by supervisory, maintenance, and operating personnel, large as these problems may be, are all progressing rapidly through education, technological advances, and job training.

The industrial instrument industry is ready, willing, and competent to keep pace with technical progress in every field of manufacturing as surely desired by all industrial management.

Q. What is the definition of pulp density in the mineral industry?

A. Pulp density in the mineral industry is weight per unit volume compared to water.

Q. Would the bubble method be satisfactory for paper pulp consistency regulation?

A. I do not believe that the bubble method would be satisfactory for consistency regulation, due to the small difference in density between saturated pulp and water. "Viscosity" measurements may approach the desired measurement above 2% consistency.

Some Aspects of Instrumentation in the Distilling Industry

IRVING LEFKOWITZ

THIS paper describes some aspects of the instrumentation work done at the distillery plants of Joseph E. Seagram & Sons, Inc., as an example of "another industry's experience with process measurement and control."

If one of the objectives of this portion of the Measurement and Control Conference is to present the paper industry with the challenge: "We did it and so can you!" then the distilling industry makes a particularly apt and provocative challenger since few other process industries are so well identified in the popular mind with primitiveness, empiricism, and tradition. Despite the efforts of enlightened publicity programs, the crude operations of the backwoods moonshiner do, apparently, a better job of capturing the public's imagination than the modern scientific methods of the legitimate producer. Actually, and in sharp contrast to these general impressions, some of the distilleries have been very progressive in the application of new ideas, developments, and techniques to their plant operations. As a result, these plants employ the most up-to-date equipment and processing methods consistent with a high standard of performance. In this progressive environment instrumentation has played an important role.

This paper attempts to present some of the general ideas and principles which guided the instrumentation program. Specific distillery processes and control installations are described in some detail only to point up the practical applications of these principles. Since the processes considered involve, for the most part, standard unit operations, the principles and methods outlined should have universal application.

The approach to automatic process control has been rather basic. It is assumed that optimum conditions of operation of the process have been determined through laboratory experimentation, pilot-plant development, and accumulated production "know-how." Deviations of these operating conditions from their desired values affect adversely the rate, efficiency, and quality of production. Therefore, the process instrumentation should provide effective means of reproducing and maintaining at optimum levels those temperatures, pressures, concentrations, etc. which define the process performance.

A direct relationship is observed between the degree of control and the quality of the product. Since random variations

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in the process operating conditions affect the composition and purity of the material produced, either the specifications for the end product must fit an average production quality or a large percentage rejection must be accepted. In general, therefore, product quality standards can be raised by reducing the amplitude of such variations through adequate control means. This point is particularly important in the production of beverage spirits because of the following factors:

1. Product quality is expressed in terms of its taste and odor. Since instrumental methods for measuring taste and olfactory sensations have not yet been developed, indirect means of definition and control must be employed in the plant processing.

2. The taste and odor of the product are functions of the minute concentrations of a variety of organic compounds called congeners, which are produced as by-products of the processing. These congeners affect the product quality down to traces of the order of parts per million. The direct measurement and control of these trace constituents on an industrial scale are extremely difficult.

3. Government regulations and high excise taxes peculiar to the distilling industry impose various economic and other limitations on the methods of processing.

For maximum performance of both equipment and control system, the instrumentation must be engineered into the initial process design. Unfortunately, this practice is more the exception than the rule. It is still common to treat measuring and control devices as process appendages to be added or subtracted as conditions of operation suggest with a minimum of consideration to underlying causal relationships and process response characteristics. Thus the problem of temperature control of a reaction vessel may be treated in almost the same detached terms as the application of a thermostat control to a hot water heater. Naturally this puts the control system under a handicap which may be serious enough to prevent satisfactory operation.

An adequate control system which can compensate for process variations reduces the need for such averaging techniques as surge tanks, stabilizing sections, and capacity chambers. By the same token, overdesign of the equipment to provide a suitable safety margin can be minimized. The real savings in equipment, plant area, and material in process inventory may far outweigh the cost of the instrumentation.

In response to these ideas, an active instrument research group was maintained for the purpose of developing improved methods of measurement and control for distillery process applications. The instrumentation for all new and revised installations was designed and specified by company personnel. In general, the specifications were built around standard, commercially available components. In this connection, new instruments were tested to evaluate their performance characteristics and determine their range of applications and specific limitations with respect to distillery operations. In some instances where a device with desired functions or properties was not available, a suitable unit was designed and fabricated. Two such examples which will be mentioned later are an instrument for measuring the alcohol concentration inside the distillation column and one for controlling the rate of grain flow into the cooking system.

It will be helpful, before discussing the actual control systems to survey briefly the operations that go into the production of beverage spirits. This processing takes on three main phases: (1) conversion of the starches in various grains to ethyl or grain alcohol, (2) concentration and purification of the alcohol product, and (3) recovery of the by-products.

Figure 1 shows the sequence of operations in simplified block diagram form. Various cereal grains such as corn, wheat, and rye are used, depending upon the type of product to be produced. The grain is ground, then cooked at elevated temperatures and pressures to break down the complex starches into simpler molecules. The cooked starches are readily converted into fermentable sugars by the enzymes contained in germinated grain or barley malt. The malt is separately ground and added to the system at this point. The resulting mash, as it is called, is mixed with a yeast slurry in large enclosed tanks and allowed to ferment over a period of from 40 to 80 hr. The yeast cells convert the sugars into alcohol as part of their life process. The yeast is grown in a separate yeasting operation where the organisms are allowed to multiply from test-tube proportions to a final volume of several thousand gallons. The fermented mash is called beer. It contains from 6 to 8% alcohol in a heterogeneous mixture of spent grain, water, and a variety of organic con-

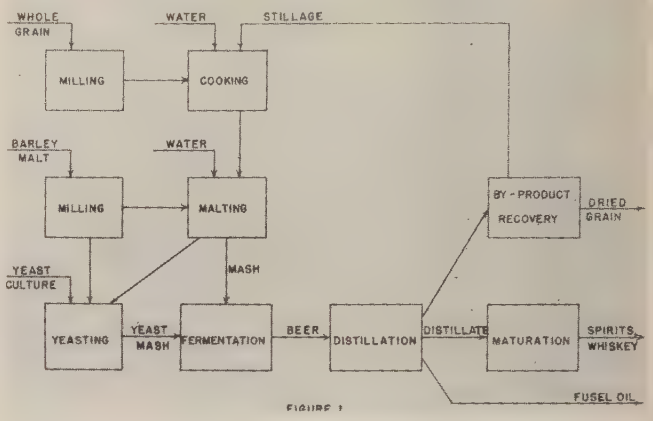

Fig. 1. Distillery operations

stituents (congeners) formed in the cooking and fermenting operations. The function of the distillation, therefore, is to separate the alcohol from this mixture, bring it up to the desired concentration or proof, and eliminate most of the congener content. The alcohol product or distillate is then barrelled and put into warehouses for aging. Depending upon the previous processing, this product will be either a straight whiskey or grain neutral spirits used in blending. The major congener, fusel oil, has commercial value as a solvent ingredient and is therefore concentrated and sold to the chemical industry. The alcohol-free liquor (stillage) contains suspended and dissolved solids of a high protein content. These solids are concentrated and dried in the by-product recovery operation. The resultant material forms an important constituent of animal feeds. It is to be noted that part of the stillage feed to the by-product recovery is recirculated back into the cookers. This stillage plays an important part in establishing the proper pH conditions in the cooking and fermentation.

All of the operations, with the exception of yeasting, fermentation and maturation are of the continuous type. This means not only continuous material flows from one operation to the next, but also a close interrelationship of process variables. These functional tie-ins must be taken into account in the control system designs. This factor is particularly important in the distillery because of the many significant sources of process variations over which there is little or no direct control. These include: (1) the available starch content of the grains, (2) the enzyme activity of the malt, (3) the fermenting activity of the yeast, and (4) the activity of contaminating microorganisms.

The effect of these variables is to introduce load changes at various stages of the processing. In other words, a constant grain input does not result in a constant product output. It is not sufficient, therefore, to provide for a system of independent controllers which will maintain a set of fixed relationships. The control system must, for optimum performance, sense and correct for load changes through suitable manipulation of the variables.

A schematic representation of a part of the cooking system is shown in Fig. 2. Grain, water, and stillage are mixed together in the precooker vessel. The resulting slurry is pumped into the cooking tube where it is rapidly raised to the cooking temperature and pressure. The holding time, a matter of minutes, is determined by the time it takes the slurry to flow through the tube. The discharge stream is flashed to almost atmospheric pressure in the flash chamber, permitting recovery of low-pressure steam. The cook is cooled further through several stages of evaporative cooling (only two vacuum chambers are shown). At one intermediate stage, the malt slurry is added for conversion. The final cooling stage brings the temperature down to that required for the fermentation and the discharge flow is pumped directly to the fermenters.

Temperature is the most important criterion of operation in the cooking process because the transformations involved are essentially chemical in nature. The rate of these reac-

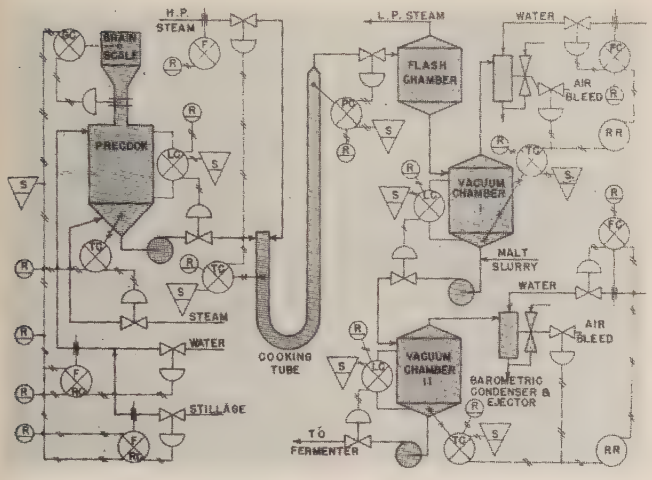

Fig. 2. Cooker control system

tions increases as the temperature is increased. However, beyond a certain critical value, the trend is reversed due to breakdown of some of the organic material or destruction of the active agents. For example, a slight increase in malting temperature above the operating level results in destruction of the malt enzymes' activity. Therefore, fairly well-defined temperature optimums exist and the conversion efficiency or yield at each step of the processing is directly related to the quality of the temperature control.

Temperature is controlled in the precooker and cooking tube by regulating the flow of steam into the respective chambers. The control of vacuum chamber temperature is not quite as straightforward. The temperature is a function of the vacuum in the chamber which in turn depends on the operation of the barometric condenser and steam ejector equipment. Rapid control over the vacuum is effected by regulating the amount of air bled into the system. However, this method can be quite inefficient over a wide range of loads. The vacuum is also affected by the flow of water into the condenser. The disadvantage here is its slow response. Good results are obtained by a combination of the two control actions. A change in temperature produces an immediate corrective action through the air bleed control. A slow resetting action then adjusts the condenser water flow to compensate for any load change that occurred. At balance, the air bleed control is returned to mid-position so that it can exercise maximum effectiveness in response to process deviations.

Proportional-type level controllers are provided on the precooker and vacuum chambers to ensure smooth continuity of operations and to permit maximum utilization of the chamber capacities without danger of overflow.

Pressure is controlled in the cooking tube by throttling the discharge valve. The purpose of this control is to maintain the cooking pressure above saturation, thereby preventing flashing in the tube. This is important for two reasons. First, flashing represents a substantial waste of high-pressure steam and second, the presence of vapors cuts down the effective volume of the tube, resulting in uncontrolled variations in cooking time.

The effect of pH and starch concentration on the cooking and fermentation reactions is also an important factor to be considered. These variables are indirectly controlled by flow ratio control of grain, water, and stillage feeds to the precooker. This will maintain concentration and pH values constant providing that the grain and stillage are of constant composition. Strictly speaking the instrumentation on this unit is incomplete to the extent that direct means for measuring and controlling these variables were not provided. Of course, the reason they were not provided was the unavailability of suitable instruments at a cost that could be justified.

A specially designed device is used for the control of the grain feed. Semiautomatic hopper-type scales are employed for weighing the grain. The control device varies the grain flow out of the scale in such a manner as to maintain some preset frequency of scale dumps which in turn is a direct measure of the grain flow. The control device is set pneumatically by the same pressure that actuates the water and stillage ratio controllers. In this way, the relative proportions of grain, water, and stillage in the process stream are maintained constant.

In general, all measuring instruments in this system are pneumatic transmitters located at the point of measurement. The value of the measurement is transmitted to a multipen recorder located on the panel board. Each controller is situated close to the point of control and can be remote set from the panel board.

The control system for the distillation process presents some interesting features. Here the actions are physical rather than chemical and vapor pressure and concentration displace temperature as the important criteria of operation.

A typical distilling column is shown schematically in Fig. 3. Actually, this represents but one of a number of interconnected fractionating columns each of which performs a specific function in the concentration and purification of the product. Some liberties have been taken in omitting and rearranging a few of the lines in order to simplify the presentation.

Feed, consisting of an alcohol-water solution containing small amounts of various congeners enters the column at some intermediate point. The alcohol, being more volatile, rises in the column while the water tends toward the base. The alcohol product is drawn off the condenser and alcohol-free water is pumped out the bottom. Some of the congeners termed fusel oil, tend to concentrate in a relatively narrow band just slightly above the feed point. These are removed from the system through a small side draw referred to as the fusel oil draw. Other congeners tend to concentrate elsewhere in the column and can be withdrawn through appropriately located taps. However, since the same control principles apply, these are not included in the discussion. Steam enters the base of the column, producing alcohol-water vapors which work their way up the column, and are finally condensed in the condenser. Part of the condensate is drawn off as product, the remainder is returned to the column as reflux.

In order for the column to function properly and remain in equilibrium, several rather obvious conditions must be satisfied:

1. Material Balance: The quality of alcohol entering in the feed must equal the total leaving in the product and fusel oil draw streams. Any discrepancy between input and out-

put results in either an accumulation or depletion of alcohol in the column, leading, respectively, to alcohol losses out the bottom or a lowering of the product concentration.

Similarly, congeners must be withdrawn from the column at a rate equal to their entry in the feed. Too low a draw rate causes an accumulation in the column, leading ultimately

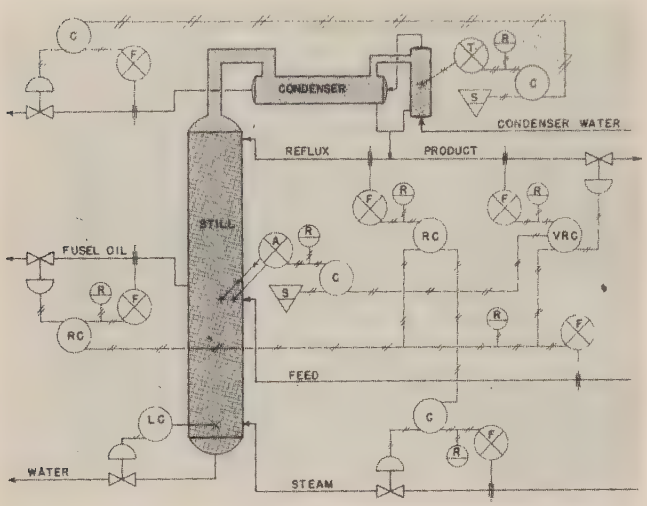

Fig. 3. Distillation control system

to their build-up in the product stream. Too high a draw rate adds to the load on the system with a subsequent lowering of the over-all efficiency.

2. Energy Balance: Energy is supplied to the column in the form of steam. Too little steam will not do the job and too much is poor economy.

Energy is absorbed by the condenser cooling water. The heat removal should be just enough to condense all the vapors at their saturation temperature. Insufficient cooling water results in vapor losses. Excess water, besides being wasteful, has the added disadvantage of introducing variations in the reflux temperature.

3. Alcohol Concentration Control: The location of the fusel oil concentration band is a function of the alcohol distribution in the column. In order to maintain maximum fusel oil concentration at the fusel oil draw point, the alcohol composition at this point must be kept within rather narrow limits.

Alcohol material balance is maintained by the flow ratio control of all the draw streams to the feed flow. The feed will vary as a result of operating and load variations in preceding columns. However, the draw streams will be varied in the proper proportions to satisfy the material balance. By the same token, congener balance is maintained by ratio controlling the side draws in proportion to their concentration in the feed. By this means the concentration in the column is kept within safe limits.

The reflux ratio, which is the ratio of the reflux flow to the product flow, determines to a large extent the alcohol distribution in the column. It is desired for column stability to maintain this ratio constant. Since the product flow is already proportioned to the feed, ratio control of the reflux to the feed will result in a constant reflux-product flow ratio. Inasmuch as the reflux flow is the difference between the total overhead and the product flow, it must be controlled by suitable manipulation of the steam flow.

Theoretically, the control system outlined thus far should be capable of maintaining column equilibrium. However, the analysis is based on an assumption of constant composition of the various flow steams. In practice this is not exactly true and since the effects on the column are cumulative, any deviation in composition will lead ultimately to a change in equilibrium. An end-point controller is employed to detect and compensate for such deviations. This is an instrument responding to alcohol concentration which is installed in the column at the fusel oil draw point. Any build-up or depletion of alcohol results in a change in concentration which is detected by the instrument. This change is interpreted as an error in ratio setting between product flow and feed. The product flow is controlled by a pnuematically variable ratio controller which permits automatic resetting of the flow ratio. The product is still ratioed to the feed, however, the ratio is automatically determined by the output of the concentration controller. Thus, a change in load on the column is immediately compensated by a proportionate change in product draw. Any additional correction required is then applied by the concentration controller.

The concentration instrument was specifically developed for this control system. Its operation is based upon a comparison of the vapor pressure of the material in the column with that of a reference solution of known composition maintained at the same temperature. Within the useful range of the instrument, the difference in vapor pressure is directly proportional to the difference in alcohol concentration between the reference and the liquid in the column.

The purpose of the condenser control is to reduce the cooling water demand to a minimum consistent with negligible vapor losses out the vent. This is accomplished by means of a long, averaging type temperature element located in a second, small condenser unit. The bulb is parallel to the vapor flow and essentially measures the transition point from vapors to all condensate. The controller regulates the water flow to maintain this condensation band within the length of the temperature element.

It is to be noted that the temperature controller acts through a water flow controller rather than on the water flow directly. This cascading of controls has advantages where the process or measuring lag is appreciable.

1. It permits an accurately defined relationship to be maintained between the primary and secondary controlled variables without regard to valve characteristics.

2. It eliminates the variation of flow due to line pressure and other variations.

3. It permits the application of flow limits where necessary

There are some elements missing from the distillation control system. The most significant are instruments for measuring the alcohol concentration in the base water flow and instruments for measuring congener concentration at the fusel oil draw point. In practice an excess of steam is maintained on the column to keep the base losses negligible. With a suitable base loss controller, this excess could be materially reduced. Similarly, in the absence of automatic control of the congener concentrations, the congener draw-off streams are maintained substantially greater than the minimum required in order to provide an adequate margin of safety.

In general, the following rules have been followed in designing process control systems:

1. Measuring and control instruments are located at the point of application with signals transmitted to the panel board for recording and remote actuation.

2. Flow-ratio contro's are employed to maintain material and energy balances.

3. Cascaded controls are used to compensate for unfavorable process lags.

4. End-point controllers are used to compensate for the inadequacies of the flow-ratio control system.

Control systems for most of the distillery processes have been designed and put into practice. It has been possible, in many of these appilcations, to demonstrate directly the specific contributions of the instrumentation to process improvement in terms of higher efficiencies of operation or greater product uniformity.

A Quality Control Program

JOHN F. LANGMAID, JR.

Irving Lefkowitz, Case Institute of Technology

J. F. Langmaid, Jr., S. D. Warren Co.

I HAVE a cartoon on my office wall. It depicts two long-haired scientists surrounded by many complicated instruments and gadgets. They apparently are involved in quite an important problem and at the moment are examining closely a continuous sheet of graph paper. The caption under the cartoon says, "Have you corrected for daylight saving time?" It is obvious that these men are confused and perhaps have not included all the variables in their experiment that they should. I think that is the way many of us feel when we begin to plan a quality control program. There are so many variables in paper that we sometimes wonder just where to start. My discussion, I hope, will help you in planning a new quality control program if you do not already have one or in revising your present program if you are not satisfied just the way things are going.

The talks that you have already heard have dealt primarily with instruments and controls on your operating equipment. In order that these controls be of maximum value to your operating personnel, it is necessary to have a quality control organization that will evaluate the product you are making and relate this back to the machine controls.

There are two kinds of quality control programs that could be set up. One is the inspection of the product after it is made so as to determine whether the product is acceptable or must be rejected. The second program deals with the control of the product as it is being made, and this is the one that we will discuss. This is known as process control and has to do with the proper manufacture of the product at the time it is being made and not after all the damage is done, if such is the case.

Before setting up a quality control program we should consider why one is needed. Basically, of course, it is because of variability. We all know this but we don't very often stop to think about it and analyze it as we must if a quality control program is to be a success.

Warren Purcell, quality control manager for the Brown Co. in Berlin, N. H., has the following to say about variability in the paper industry: "The composition and texture of wood varies from forest to forest, between different parts of the same forest, from year to year, from season to season, from tree to tree, and between different parts of the same tree. This variation is caused by a tremendous multitude of factors which themselves depend on weather conditions and other natural forces which act in an endless procession of variability. Trees are harvested by variable men, and logs are shipped to mills to be processed into pulp and paper. The processing is done by persons and persons who themselves vary among one another in age, sex, aptitude, skill, temperament, etc. And each individual person varies in many of these characteristics from year to year, from day to day, even from hour to hour. In doing the processing these variable persons starting with variable raw materials use equipment which has been designed by variable persons and built by other variable persons out of other variable raw materials. The finished product is inspected by variable persons using equipment designed and constructed out of variable materials by other variable persons. Finally, the finished product is used by other variable persons and if the customer is himself a manufacturer he is again subject to the long chain of complex variability." I think that is a wonderful description of variability in our industry.

As variability is the foundation of any quality control program, our first step is to make a study of variability as it affects the various characteristics that we wish to measure. We will find that there is a certain amount of inherent variability in the process and this will show itself in the normal ups and downs that we get in our test results when it is running normally. We will also find that there are unusual variations, and these will occur when some assignable cause is acting on the system. When we know what the inherent variability is we know what to expect from test to test, and as long as we remain within this amount of variability no process changes need be attempted. On the other hand, if things don't seem to be happening in this normal pattern of variability then there is pretty good reason to suspect that something unusual has happened, and it is time to take action.

Our study of variability was made as follows, and I don't claim that this is the best way or the only way. All of our tests that are made on paper; that is, such things as basis weight, tear, burst, opacity, ash, etc., are recorded on the usual type of log sheets. We went back over a period of 6 to 8 months and using the data, as recorded, we broke the data down into subgroups of four, taking four consecutive tests as one subgroup, and then the next four as the second subgroup, etc. Approximately 50 subgroups were assembled, and the average and the range calculated. From the range, we calculated the standard deviation. Using the proper statistical tables some of our data were found to be outside the normal variability, and these were thrown out and the standard deviation recalculated. This process was continued until all the remaining data were in control, and this we considered to be a measure of the inherent variability of the particular test under study.

There will be some that will say this is not a true estimate of the inherent variability. However, for our purpose, we believe it is the type of variability that we are interested in for economic process control as it takes into account all of the variables that are acting on the system when satisfactory quality paper is being made.

The inherent variability values we have now established are defined as the standard deviations of individual tests. For those of you who are not familiar with statistical techniques an explanation of just what standard deviation is is in order.

There are two numbers, or statistics, that are very useful in describing a number of observations. One of these is the average, or measure of central tendency. The usual "average" used is the arithmetic mean and, of course, is obtained by adding up all the values and dividing by the number of observations. The other is some sort of measure of spread or dispersion of the observations. The most useful measure of spread is the standard deviation. This is the root-mean-square deviation of the observations from the average. The calculation is made by subtracting each observation from the average, squaring it, adding them all up, dividing their sum by the number of observations, and taking the square root.

These two numbers tell us a lot about the observations. They tell us the average, and that is usually a useful value to

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know, and the variation about that average which is sometimes even more useful to us.

If we know the standard deviation just what does it tell us about the spread? Just this, when the process is in statistical control approximately 67% of the values will fall within plus or minus one standard deviation of the average. Statistically, two standard deviation limits will include 95% of the variability and three standard deviation limits 99.7%. The one we choose for our limits depends on the chance we want to take of being wrong some of the time. If we pick two standard deviation limits we expect—in the long run—to have 5% of our tests outside when nothing unusual has happened. Thus, we may take action some of the time when we shouldn't. If three standard deviation limits are taken only three in 1000 results would be outside. For all practical purposes we can say that if any test is beyond these limits an assignable cause is acting on the system. Some people pick two standard deviation and some three standard deviation limits depending on their particular circumstances. I have found two standard deviation limits to be the best economic limits for our particular use and others in the paper industry have found the same. The reason why two rather than three standard deviation limits are frequently better is because the normal variations are often greater than we like even under the best conditions. From a practical, as well as economic point of view, it is better to establish narrower limits and make a process change five times out of a hundred when it is not necessary than to use the "wider than we like" limits and run the risk of not making a change when, in fact, a change may help us to reduce variability.

An example will explain the practical use of the standard deviation and the selection of the proper limits. Let's take some of the tests that I'm sure you are all familiar with—basis weight, Elmendorf, burst, opacity, and ash.

Standard deviations found from production data on these characteristics were:

Basis weight	1.0
Elmendorf	5.0
Burst	0.9
Opacity	0.8
Ash	0.8

These are all for 50-lb. book paper.

These standard deviation values calculated from the range method, as I have already explained, represent the amount of variability we can expect when the process is acting normally. If we multiply them by three we can expect all but three in 1000 tests to be plus or minus these values from the average. In every case but one—the ash test—this is too much spread. Weight would be ±3 lb. and trade customs only allow ±2½ lb. Tear is ±15, burst ±2.7, opacity ±2.4, and ash ±2.4. These are too wide for process control on the kind of product we are making.

Take opacity for instance. In 50-lb. basis weight the standard is 93% for this particular grade of paper. Paper that is 2.4 less than this, or 90.6%, is just too low. We don't want to get down this low before doing something about it.

For all of these requirements, except weight, it is not economic to make an engineering change to reduce the variability. so we set up two standard deviation limits and take action the five times in one hundred when we don't really need to. From a practical point of view I think this makes sense.

For basis weight we were not satisfied with this amount of variability. Engineering changes were made, followed by a statistical analysis of the results obtained, and the standard deviation was reduced to a point where the ±5.0% trade custom was within the three standard deviation limits.

In setting up our quality control program, we use our variability study in two ways: (1) to tell us if our natural manufacturing variation is greater than or less than our customer tolerances, and (2) as a guide in controlling the process. These two considerations lead us to two separate phases for a quality control organization, and these two should be kept separate as far as their work is concerned, and should consist of two separate groups of people although both may be operating within the same department.

To handle problems concerned with reducing inherent manufacturing variations, we should have a "research group." This group should consist of men familiar with the engineering problems involved. They would probably be drawn from the research laboratory and the production department. For example, you might set up a task group of two research men and two production men whose job it would be to work on problems of this nature submitted to them by the man in charge of the quality control program. Of course it would depend on just how far off beam the process was whether such a group would devote full or only part time to this work.

The other phase of the program is the "process control group" and is the one in which you are probably most interested. The best way I can outline this is to tell you what our program is at S. D. Warren.

First, I should say that our mill manufactures between 425 and 450 tons per day of printing papers. The grade qualities vary all the way from antique to English finish book, letterpress and offset machine coated papers, and raw stock for our coating mill.

Process control for these products starts in our control laboratory where all visual, chemical, and physical tests are made on samples from the machines. Sixteen people are employed to do the actual testing and recording of results on the control log and at the paper machines. These people work on a 6-hr. shift made up of three girls and one man per shift. Directly over these testers are the inspectors and supervising the entire control group is the superintendent who reports to the mill production manager.

From the 400 to 450 reels made per day two samples per reel are taken by the back tender. One sample is for the inspector who makes one trip per hour to all machines. His responsibility is to check each sample for general visual quality and follow the control laboratory tests, and to work closely with each machine foreman in producing quality paper meeting specifications.

The other group of samples are collected by the "runner" whose job is to post the test results on the samples from the preceding trip on the machine log and deliver the current samples to the control laboratory.

Tests on the samples are made as soon as they are delivered to the control laboratory as our objective is to have our test results posted at the machine in as short a time as possible. No conditioning of samples is done except in the case of folding endurance. This test is influenced so much by moisture content that we feel the test results would be too unreliable if we tested without conditioning. Tests are posted at the machines about 1½ hr. after the sample is taken. This is about as fast as we can do it and is about the best performance we can expect considering these testers are making about 1300 individual tests in 24 hr. or at the rate of almost one a minute.

There is always the question of just how frequently the various tests should be made. This depends of course upon the amount of variability on ony particular test and whether this variability is within specification tolerances or whether it is frequently outside. Our experience has been to make each test on the average of about once an hour. This assumes of course that things are running pretty much in control. However, when the test results are outside the tolerances then we test every reel until the test is inside specifications. At that point, we revert to one test every hour for as long as the results are within specifications.

The log sheet that we use for recording the tests is similar to one used in many mills. Across the top are listed the various types of tests and the reel numbers are written down on the left-hand side. Under each heading is written the specification for the particular test and the plus and minus tolerance.

When the tests are recorded, if they are within the tolerances they are posted in black; if the test is below the minimum specification it is posted in red; and if above the maximum specification in blue. On some tests where it is just as detrimental to be high as low, the test is always posted in red if it is outside the limits regardless of whether it is below or above. Similar log sheets are posted at each paper machine and the results of the various tests are recorded on these log sheets by the runners as I mentioned before.

The log sheet is an adaptation of the control chart. It has the disadvantage of not showing a graphic picture of the ups and downs of variability, which is desirable. Where a large number of tests are not required and physical space is not at a premium graphical representation in the form of a control chart with limits is by far the best method of recording test results. Under conditions that call for many types of tests, and a large number of paper machines are operating, conventional control charts are sometimes too cumbersome, and a compromise is desired. The log sheet fits this need very nicely as a great deal of information can be recorded in a relatively small space. Plus and minus limits are shown and when tests are exceeding the limits, it is readily apparent by the use of different colored entries on the log. The final decision on just what type of recording medium to use depends on the particular conditions under consideration.

Summing up, then, the process control department has the responsibility of: (1) setting specifications; (2) establishing tolerances that are satisfactory to the customer and at the same time are within the economic and practical limits of production controls; (3) testing the product during manufacture frequently and rapidly; (4) reporting the test results in such a manner that they can be easily interpreted by the inspectors and production personnel; and (5) making disposition of questionable and substandard product.

An adjunct to our process control laboratory, and a very important part of our quality control program, is our printing-testing department. As primarily manufacturers of printing papers, it is vital that we know just how our product will perform in the customer's plant. All of the physical tests made in our control laboratory are a means to this end, but nothing will tell us just what the printing quality from run to run and within a run will be as well as actually printing the paper.

To meet the needs of this kind of control our printing-testing department is equipped with a 36 by 50 Miehle and a no. 29 Miehle press for testing papers to be printed by the letterpress process, and a 17 by 22 Harris offset press for testing the lithographic papers. There is also a Cleveland folder for checking the folding properties of paper.

For full-coated and machine-coated papers the printing plate used contains a 150-line screen halftone and a solid. For E.F. and M/C pigmented papers a 120-line screen is used. A commercial letterpress black ink is used and the same makeready is employed on all tests. All press conditions are kept as uniform as possible for all control tests.

This testing work is done during the day shift only. Samples from all coated and machine-coated orders are taken by the machine operators during the night shifts and collected at 7:00 a.m. for the morning test. Those taken during the day are tested during the afternoon. A composite sample from E.F. grades is tested: 17 by 22 sheets are cut from all samples, assembled by grade and basis weight, and piled on the feed board of the press. Twenty or so standard sheets are run through the press first to adjust the ink flow for the proper ink film thickness. As soon as press conditions are right all of the test sheets are run through. The only adjustment made is for extreme differences in basis weight. In such cases, the amount of packing has to be changed so as to have nearly as possible the same amount of impression on all sheets.

The evaluation of the printed results is made by comparing each sheet with a set of graduated "standards." Seven printed sheets ranging from a perfect printed sheet to a mediocre one and rated 100% down to 70% at 5% intervals are used as standards. As each sheet is inspected it is given a rating and then is recorded on a special form for this purpose. The black solid is also examined closely for fine pepper picking which would indicate a weak bond between the coating and the base paper. A printing report goes to the proper department head where the required action is taken on paper not meeting specifications.

Reject levels are established for each grade classification. For example, no. 1 coateds must print 90% or better; no. 2 coateds 85% or better, etc. Any roll falling below the minimum is "held up" and reprocessed, as for example recalendering, or put into seconds.

This type of testing does two things for us: (1) for customer acceptance it gives us a measurable yardstick by which we can weed out substandard product, and (2) for quality evaluation it gives us a method of determining the uniformity of printing from roll to roll, order to order, day to day, month to month, and from one year to the next.

A statistical report is made each month broken down by grade and basis weight and showing the number of rolls printing in each rating class. This report is followed closely by management.

For lithographic papers the testing is done somewhat differently as we are making a slightly different type of evaluation. Here we are not so much interested in the actual halftone dot reproduction (because the printing quality between sheets within a grade does not vary with paper surface differences to the degree it does in letterpress), but with the ability of a large number of sheets to be printed at high speed without anything coming from the sheet, depositing on the blanket or plate and interfering with the printed result.

Sufficient paper is taken from the machines running lithographic papers at 3-hr. intervals to supply approximately 500 sheets 17 by 22 long grain. Each lot is run under standard conditions on the Harris offset press at 5000 impressions per hr.

Evaluation is made in two ways. First, the blanket is examined for particles that may have picked out of the surface and for fiber accumulation and pigment build. Any tendency toward either of these conditions would mean extra wash-up time for the printer resulting in costs above those he may have estimated. Second, the printed sheets are examined for printing quality. Pickouts, fibering, pigment build, etc., have varying effects on the printed result.

A report form is filled out for each lot and is handled more or less the same way as the letterpress reports.

I mentioned that we had a Cleveland folder. One sample from each customer's order is dried out in a chamber controlled at 15% R.H. This sheet is then run through the folder giving a fold each way of the grain. The cross-grain fold is compared with a standard and a numerical rating given. If the rating fails to meet the minimum standard the order is rejected. Statistical records show us the variability in this characteristic from time to time.

All of these process control and testing procedures are fine and a wonderful thing, but they are costly. In fact, we spend about $100,000 per year on the ones I have covered today, and they are by no means all that we have in our company. Therefore, the question always asked is, "Do they pay their way?" I certainly believe they do.

In 1935 we had no process control laboratory such as we have today. At that time there were no testers—the inspector tested his own samples twice a shift. He made an Elmendorf and a burst test—that's all. Each morning one of the research boys collected a few sheets from all machines and made sizing and ash tests. As a practical matter we had no process control at all. The degree to which the inspectors could evaluate the paper by looking at it, feeling it, and tearing it determined the process changes required, and its acceptance or rejection. Those men had to be good and they were.

Today I don't think we would be in business if we were operating under those conditions. The complexities of manufacture with wider and higher speed machines, machine coating, more exacting paper tolerances to perform properly on larger and faster presses, and many others make a quality control program a requirement for keeping costs down and quality up. Our records show conclusively that without these controls we would be rejecting many times the volume of paper we do today. And even more important than this is that we know the kind of product going out the mill door.

In industry after industry, it has proved that a good quality control program is almost a criterion for staying in business. Paper mills are gradually finding that to be competitive under today's requirements, they must give good value for the customer's dollar. A well-planned and executed quality control program will pay dividends.

Q. Do you make rotogravure paper and how is it tested?
A. We make very little rotogravure paper and therefore we do not test for its printability.
Q. What is done about offgrade paper?
A. This decision is up to the quality control superintendent. If the quantity involved is large other people may be brought into the discussion. This is possible in only 3 to 5% of the cases.
Q. What control do you use to test for 'picking?'
A. We have developed our own test known as an M-P or machine print test. Standards are selected from actual commercial tests that print satisfactorily by letterpress and offset. A comparison is made of the "standard" and the paper to be tested by printing a black solid on both sheets. The speed at which the paper is pulled from the plate is variable and is increased until one of the two sheets picks. If the "standard" picks first then it is weaker than the test sheet and vice versa. A testing instrument similar to ours is now manufactured by Waldron Machine Co. in New Brunswick, N. J. Also the Lithographic Technical Foundation is experimenting with such a machine, and I believe Hercules Powder Co. is too.

The Human Being—the Most Difficult Measurement and Control Problem of All

H. A. BLACK

When your chairman sent me a copy of the program for this conference on measurement and control in the paper industry, I was struck with a deep sense of humility. In looking over the subjects listed for discussion, I was impressed by the wonderful state of advancement which you scientists and engineers have reached in measuring and controlling the mechanisms and processes of production as compared with the rather primitive state of development of the science of human engineering, with the systems and instruments of personnnel and industrial relations management.

However, shortly after reading this program and before coming here, I gained some partial reassurance after being involved in a couple of labor relations problems which indicated that you gentlemen have not yet reached Utopia. You have not solved all of the problems of measurement and control in our industry.

One of these matters had to do with wood scaling. Of all the inaccurate and unscientific procedures for measurment existing in the paper industry today, this one seems to me to be the most archaic; and yet, on the woodscaler's say-so, we spend millions of dollars annually. It is somewhat astounding and, as I said, reassuring to find that with all of your technical know-how, you haven't found a better method, a better way for measuring the volume and density of this important raw material used in our industry. I know that you must be working on this problem.

H. A. Black, Director of Industrial Relations, Mead Corp., Chillicothe, Ohio.

While you are at it, may I suggest that another fertile field for your endeavors lies in the hand sorting, counting, and inspection of fine printing papers? This activity, too, is in a pretty elementary stage of evolution insofar as measurement and control are concerned.

I know you didn't ask me to come here to criticize your methods and techniques, to point out the areas where your science and systems need to be expanded and improved. I assume that the reverse is true—you brought me here because you were critical or skeptical of the work we are doing in the field of human relations and personnel measurement and control; or you were at least concerned about the vast magnitude of the problem.

H. A. Black, Mead Corp.

All of us recognize, by the subject to which this meeting is devoted, that every organization needs internal checks and controls to hold it together. We recognize this particularly in the human area because: first, we are constantly being confronted with the shortcomings and inadequacies of people; and because we feel the urgent need for some kind of cement or glue, some kind of adhesive, to hold the cells of the human organization together in a kind of unity.

The subject which has been assigned me—"The Human Being, the Most Difficult Measurement and Control Problem of All"—in effect, asks this question: what have you industrial relations soothsayers, you staff experts who are always telling us how to run our businesses, what have you got to offer that will do the measurement and control job for us in the human area as well as our pH meters, our betatrons, and our audio gages will do in the measurement and control of production?

Fortunately, or unfortunately, depending upon your point of view, we have no miracles to perform, no magic formulas for solving our human relations problems. But we are not completely without resources. In the industrial relations field we do have some measuring instruments, some control devices which, while they are not as precise as your electronic gadgets, are a step in this direction. Although you are familiar with most of these personnel devices, let me list a few of them just for the purpose of refreshing your memory.

In the field of employee evaluation, in the hiring, selection, placement, and transfer of employees, we are fast developing a system of measurement calculated to improve the quality of these important personnel functions. To mention a few: psychological testing, aptitude or ability and skill measurement, is rapidly coming into its own as a scientific aid in the prediction of employee success or failure in a given occupation or field of work. While it has not improved to the point where we can assure you that all of the square pegs will be placed in the square holes, reliable tests, properly used, can be an important asset to other selection procedures in improving upon the variability of chance in employee selection.

The personal interview, another widely used selection tool, is being systematized and made more reliable by the use of a variety of techniques. These include the use of interviewing check-lists, interviewing guides, and more recently, the so-called patterned interview in which the interviewer seeks to secure specific information on a number of points of an applicant's background which have been determined in advance to be significant or important to his success in the job or position under consideration.

In evaluating employee on-the-job performance, a number of new merit rating techniques are being employed. They have such names as the forced choice system, the critical incident review, and the field review method of employee appraisal. Without going into any description of these techniques, suffice it to say that they are calculated to make employee evaluation more objective, to remove or minimize the natural human tendency toward prejudice and bias which are so prevalent when one human being attempts to pass judgment upon another. In other words, to make these measurements more accurate and more precise.

Job analysis is another valuable measurement and control tool of the personnel executive. Fundamentally, this is the process of determining by observation and study the nature of a job as it affects the worker, or as it affects the operation or process. From this basic tool we derive:

1. Job specifications useful in selection and placement and in determination of training requirements.

2. Job evaluation widely used as a systematic, if not a scientific, method of establishing equitable wage and salary rates.

3. From job analysis also springs the great field of methods analysis, and time and motion study with its many industrial engineering purposes. We could devote the whole evening to a discussion of the measurement and control implications and achievements in this area alone.

In still another way, in attitude measurement, we are employing some fairly good measurement devices. Typically, in surveying attitudes we use either a standardized anonymous questionnaire administered to all employees—a method with which I assume you are familiar. Or, we can use various types of clinical, or depth, interviews to gather facts or opinions from workers which they will not freely express to their bosses.

In the training field, too, much is being accomplished. By careful application of the psychologist's knowledge of the principles of learning, we are improving our industrial training programs, achieving better, faster, and more uniform results.

These are a few of the tools of measurement and control available in the field of personnel management. They are the stock in trade, the bread and butter of people in jobs such as mine. Unfortunately, too few managements know how to take advantage of or how to use these measuring instruments properly for the purposes of gaining effective personnel control. It is my understanding that the same problem exists to some extent in the application of the tools of measurement in the manufacturing and production area.

Perhaps more impressive than this somewhat abbreviated list of personnel measuring instruments and control devices would be a list of the areas of human activity in which we do not have any very good measurement and, as a result, fairly little control. I will not presume to bore you with a lengthy recital of these but there are a couple which I would like to call to your attention.

In the first place, we have failed to establish in our business systems an effective method of human communication for passing information up and down through the organization. We have not mastered the simple art of talking to one another. Part of our difficulty stems from the fact that the English language is an extremely imprecise instrument. It simply does not function with the perfection of the electric impulse in activating machines and equipment. This fact is not too often appreciated and, as a result, misunderstanding develops when one man assumes that another uses words just as he does. This is one of the most serious obstacles to effective thinking and to human communication.

Another barrier to effective communication is represented by the person who takes it for granted that anyone who does not feel the way he does about something is a fool. What is important here is not that men disagree but that they become disagreeable about it. Industry has recently begun to spend large sums in an effort to achieve better communications. To what extent these efforts will succeed or fail remains to be seen. It is my opinion that in these efforts we should place our greatest emphasis upon improving personal communication. I can hardly overemphasize a belief in face-to-face communication between a man and his immediate boss as obviously being not only more flexible in meeting the problems that come up with each employee but as being the most effective in terms of employee response and interest and in obtaining his confidence in the person issuing the communication.

In still another important area of industrial human experience, we are also woefully lacking both in measurement and control and in knowledge and skill. This is in the field of labor relations, or union-management relations.

American management is going off in about six different directions all at the same time in an effort to achieve some stability, some control in the immediate pressing, and often harassing field of dealing with organized labor. These efforts range all the way from advocacy of tighter federal and state laws regulating the activity of unions to emphasis upon plans for greater joint union-management cooperation. Still other managements advocate, or are attempting to install, broad social programs for improving employee relations, calculated in some cases to outunion the unions.

Now, this is a great huge subject, and we cannot expect to cover it here. However, in passing I cannot help but express a belief in the unrealistic nature of many of these divergent tactics. It would seem that for the present, at least, our best hope for taking the measure of our labor relations problem and our best chance for instituting some control in the situation is for managment to recognize the union for what it is. A union is a power organization, and a political organization, which has a legitimate right for existence in our industrial society, and it exists for purposes some of which will not always be identical with those of management.

If we approach the problem of labor relations, if we conduct our collective bargaining in the light of intelligent self-interest, attempting to reach agreement based upon acceptance of common goals; and where these goals are divergent by an equitable balancing of opposed strengths, by these methods we will, in my opinion, have a greater chance of achieving the control and stability in labor relations which is essential to the efficient operation of our enterprises.

I have tried to indicate briefly some of the measurement and control devices available to the management of men, the control of the human being. Also, a couple of areas where we have no very good systems, no very accurate yardsticks.

Now, what are we going to do about this problem? With your help, with the genius of you engineers, you scientists, you technicians, we are already doing something about it. We are eliminating the human being from our industrial process. Each new production line, almost every new machine, each new paper or paperboard mill uses less and less people. This is one of the secrets of the productive genius of American industry; more and more goods and services using less and less human effort.

No one can quarrel with this objective, but this is only part of the picture. When the human being cannot be eliminated for one reason or another, we have substituted for his judgment, his discretion, and his responsibility; we have substituted the machine, the instrument, and the push button. We have broken down the creative function of the worker into simple elemental tasks so that the possibility for human error and failure, short of outright nonperformance, is greatly minimized.

The American assembly line is the most outstanding example of this. This tendency is based upon the assumption that the proper approach to measurement and control in the human area is to eliminate human variability and hu-

man failure by introducing more automatic machines and more foolproof processes. Neither will we quarrel with this assumption for it would be of little use. This trend will be continued in spite of what we might say. However, we would like to suggest that some of the measurement and control devices available to the personnel manager, better selection and training, for example, can be of help, can make a significant contribution, can provide a better adjustment of men to these new machines and job processes and will thus assist with the achievement of this objective.

More important for us to consider is the effect of these trends in industry. It is becoming apparent that much of the employee unrest and employee dissatisfaction so prevalent in our industrial society can be directly traced to the success of the principle described; that is the elimination or minimization of the human factor in production. Perhaps we have too much measurement, too much control of the human element. Maybe we have gone too far with man in our efforts to achieve efficiency and standardization.

Seriously, it is about time that we gave some consideration to adjusting our industrial environment to fit the needs and personalities of men rather than the other way around. To do this will require adoption of a new point of view; some reorientation in our thinking. It will require of you engineers an approach to the design of machines and equipment in terms of the people who operate them rather than in the terms of the function and performance of the machine itself.

With this purpose in mind, efforts can be made to reduce monotony and fatigue of the machine-paced and repetitive jobs. The rotational assignment of employees who are working on monotonous and fatiguing jobs, the expansion or rearrangement on the job cycle so that jobs can encompass a larger number of varied operations, and the provision for more opportunities for teamplay and teamwork are only a few of the possibilities to be considered in the design and layout of industrial process under this new idea.

Our problem may not be more measurement and control of the human being but more measurement and control of the organization of our industrial plants, equipment, and processes. Rather than creating an environment in which the individual, the human being, will be more standardized, perhaps we need one in which he can be decontrolled, so to speak, in which there is opportunity for his growth, for maximization of his creative abilities. We need an industrial system which makes it easier for people to work together productively, in which the worker can achieve a sense of fulfillment so that his work life will have more meaning and more purpose.

Coupled with this new look at our organization, at the reorientation of purpose in our efforts at measurement and control, I would also like to suggest that we begin with efforts of achieving self-control. It seems to me particularly important that those of us in management and supervisory positions begin by getting to know ourselves better. If, by soul-searching self-analysis, we can take the measure of ourselves, if we do this thoroughly and conscientiously, we cannot help but emerge from the examination of our own limitations with anything but a deep sense of humility.

"The Human Being, the Most Difficult Measurement and Control Problem of All". . . . Yes, that is true, but it is not a hopeless problem. Its solution offers the greatest challenge to our imagination. It will require the collective genius of all of us and the exploration of many new and interesting horizons.

An officer of a large insurance company expressed this challenge in a far better way than I could ever hope to do. I would like to close with his thoughts:

"If we can develop a religious sense of wonder, humility, and faith, it will help us to see the vision of a boundless future built by the inherent capacities of men from all walks of life and of all races, creeds, natures, and backgrounds. It is a vision of cooperation, togetherness, and sharing the great adventure. It is a vision of independence and courage that explores the far reaches of the universe and probes deep into the essence of what we call man. It is, in short, a vision of a changing, growing, and infinitely exciting world which depends for its existence upon the spirit that it is not too sure it is right, on a deep-seated desire to open our minds and our hearts to the lives of others, on the practical sense of give and take, and on our faith in the growth and development of ourselves and of our fellow men."

The Measurement and Control Conference dinner, Cleveland, Ohio, May 21, 1953

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Training and Education

TAPPI Special Report No. 397, covering training activities in the industry, was issued on June 1, 1953. At this time the recipients were requested to give the committee their thoughts on the following question:

"In which subject, or phase, of each of the three areas (supervisory, prospective supervisory, and nonsupervisory training) would you like to see the first information and recommendations developed?"

To date we have received 22 replies, the majority of which mention only one area. A digest of the replies follows:

"I believe it most important that information and recommendations be developed in the supervisory training field."

—B. J. Boerner, Gen. Personnel Mgr.
Cornell Paperboard Products Co., Milwaukee, Wis.

"It is our firm belief that supervisory training is the basic essential to the program you contemplate. . . . we feel that the investigation of a supervisory training program and a subsequent report could and would have considerable value."

—R. J. Martinson, Asst. to Dir. of Industrial Rel.
Rhinelander Paper Co., Rhinelander, Wis.

"We are very interested in the general requirements for the completion of a satisfactory basic supervisory training course. Also, in the selection and screening programs for people entering presupervisory training and the general requirements for completion."

—Jack Pound, Training Supervisor
Champion Paper and Fibre Co., Pasadena, Tex.

"A survey of our management group indicates that they are most interested in additional information on supervisory training."

—D. L. Osborne, Training Supervisor
Crown Zellerbach Corp., West Lynn, Ore.

"We would like to see the first information and recommendations developed in the following subjects: supervisory area—human relations; prospective supervisory—human relations; nonsupervisory—methods of training employees on the job."

—P. R. Clarke, Industrial Rels. Mgr.
Johns-Manville Products Corp., Jarratt, Va.

"I would personally prefer to see the first information developed on supervisory training."

—C. L. McGeath, Personnel Dir.
Hartford City Paper Co., Hartford City, Ind.

"We are particularly interested at this time in information on economic education in all three areas covered by your survey."

—J. B. Morford, Mgr. Industrial & Comm. Rel.
Champion Paper and Fibre Co., Canton, N. C.

"We would like to see the first information and recommendations developed on the area of supervisory training."

—W. S. Brewster, Dir. Safety and Personnel Training
Masonite Corp., Laurel, Miss.

"The training of nonsupervisory personnel is our major problem at the moment and if any information is available, especially concerning the hours such meetings are held, we would like very much to know the practice of the leaders."

—E. L. Giffen, Personnel Representative
Detroit Sulphite Pulp & Paper Co., Detroit, Mich.

"We would like to see information on prospective supervisory training."

—Harold T. Fretz
Rayonier, Inc., Hoquiam, Wash.

"I feel that information concerning supervisory and nonsupervisory employees is of equal importance to me at this time."

—M. J. Diffley, Training Supervisor
Sealright Co., Inc., Fulton, N. Y.

"I am indicating the subjects I believe should be given consideration in the order of their importance:

Training for supervisory employees:

1. Methods of training employees on the job.
2. Human relations.
3. Supervisory responsibilities.
4. Public speaking, effective speaking, discussion leadership.
5. Economics.
6. Conference leading.

Training for prospective supervisory employees:

1. Methods of training employees on the job.
2. Human relations.
3. Public speaking, effective speaking, and writing.
4. Economics.

Training for nonsupervisory employees:

1. Induction or orientation of new employees."

—L. C. Smith, Dir. Industrial Rel. Dept.
Thilmany Pulp & Paper Co., Kaukauna, Wis.

"I regard a sound development of allocation, accept-

ance, and discharge of responsibilities as the key to success of any training program—whether supervisory or nonsupervisory—and therefore feel your initial efforts might be most helpful along this line."

—H. Wayne Smith, Training Dir., Kraft Div.
St. Regis Paper Co., New York, N. Y.

"We would be particularly interested in prospective supervisory training."

—G. F. McCrea, Div. Mgr.
The Mead Corp., Kingsport, Tenn.

"My preference for subjects for further development follows:

Supervisory training:
1. Methods of training employees on the job.
2. Company policies.

Prospective supervisory employees:
1. Supervisory responsibilities.
2. Human relations.

Nonsupervisory employees:
1. Methods of training employees on the job.
2. Manufacturing processes."

—R. E. Dever, Personnel Dir.
The Beveridge Paper Co.
Indianapolis, Ind.

"I believe that the first work for the Training and Education Committee should be in the area of supervisory employees. Training in that department on safety, human relations, and the importance of communications—both to the employees under supervision and to the management—is essential. Any other training which will help supervisory employees to understand the problems of supervision in management and to help them in managing their own departments is also important. I believe that it is important to develop training methods for supervisory employees first because they are the ones to assist in any training which is instituted for nonsupervisory employees."

—Roy L. Davis, Vice-Pres., Production
Detroit Sulphate Pulp & Paper Co., Detroit, Mich.

"Our Personnel Department is more interested in the supervisory training than the other two phases, and if it is so indicated by others who received this information on your committee work, we will be glad to have information on this phase first, although information on prospective supervisory training will also be very interesting."

—Frank Libby, Corporate Pulp & Paper Consultant
Kalamazoo Vegetable Parchment Co., Parchment, Mich.

"It is a little difficult to answer your question . . . but I believe that probably the one that is most urgently needed is to give help wherever possible to the supervisors in training the nonsupervisory employees. Actually, of course, in order to do this you must first train your supervisory group so they are capable of projecting a training program down to the nonsupervisory group."

—P. F. Peterson, Asst. to the Gen. Mgr.
Everett Pulp & Paper Co., Everett, Wash.

"We would like to see the area of prospective supervisory training develop first, and as an alternate, believe that supervisory training itself is a very close second. While nonsupervisory training is an important area of study and naturally very necessary for the proper operation of our business, it is being done, we feel, more satisfactorily by on-the-job experience than either of the other two phases."

—Mace V. Harris, Vice-Pres., Mgr. of Mfg.
Northwest Paper Co., Cloquet, Minn.

"We believe that this development should focus first on existing supervisory employees since this is the primary point at which training must take place. From there it could lead to prospective supervisory and nonsupervisory groups, but in our experience, at least, the necessity for training existing supervisors is a primary requisite."

—Maxwell D. Bardeen, Pres.
Lee Paper Co., Vicksburg, Mich.

"We believe that it would be of great interest to us to have recommendations developed on the prospective supervisory training area first. While all the areas mentioned are important, there has been a considerable amount of work done on supervisory training, and job training would probably vary much more widely by individual plants than other training areas. If we can help in studying this area, please don't hesitate to call upon us."

—T. G. Newton, Dir. of Training
Armstrong Cork Co., Lancaster, Pa.

"There is no question but what we would appreciate information and recommendations on the supervisory training as the most important training project."

—K. P. McDonough, Supervisor of Employment
St. Croix Paper Co., Woodland, Me.

J. H. Groves, *Chairman*
Union Bag & Paper Corp., Savannah, Ga.

RECENT BOOKS

Techniques of Plant Maintenance and Engineering—1953. Clapp & Poliak, Inc., 341 Madison Ave., New York, N. Y. Cloth, $8^1/_2 \times 11^1/_4$, 288 pages. $6.00.

Proceedings of the technical sessions, sponsored by The American Society of Mechanical Engineers and the Society for the Advancement of Management, held concurrently with the fourth plant maintenance show held in Cleveland in 1953.

Among the subjects covered are maintenance essentials, maintenance operating policies, preventive maintenance, maintenance of buildings, electrical equipment, mechanical equipment, power plant maintenance, corrosion prevention and control, and problems in plant engineering.

Note: Books mentioned in this column may be obtained from the Book Department of the Technical Association of the Pulp and Paper Industry, 155 E. 44th St. New York 17, N. Y.

SHIBLEY AWARD PAPERS—1953

Pacific Section, Longview, Wash., March 13, 1953

Fiber Flocculation

D. E. BEASLEY

PRODUCTION of quality paper demands good sheet formation. The continual speed-up of paper machines, with shortening of drainage times, makes the attainment of good formation more and more difficult.

Good formation requires a well-closed, homogeneous sheet which will exhibit a minimum of fiber clots. These clots, or floc as they are called, are masses of fibers with flocculate prior to formation of the sheet on the machine wire.

Some of the variables which affect flocculation are fluid viscosity, electrokinetic charge on the fibers, and consistency. Fiber-fiber collisions, dependent on one or more of these variables, always occur as an intermediate step in flocculation. Since it is impossible to eliminate all of the conditions which facilitate fiber-fiber collisions, it was decided to study the variables which might change the probability of collision, and those which tend to prevent separation of the fibers after collision.

PRELIMINARY CONSIDERATIONS

Before selecting a flocculation tester, the various types must be considered.

From a preliminary point of view, either a static or dynamic type of flocculation measurement may be made on a pulp suspension.

Equipment for a static measurement of flocculation is simple in design and construction. It consists only of a glass tank in which fiber dispersion is obtained by turbulent agitation with suitable stirrers. After the pulp is dispersed, the agitators are stopped and the degree and rate of flocculation followed visually or photographically.

Success of such an apparatus depends on how well equivalent degrees of dispersion can reproducibly be obtained by the stirring action. In any turbulent fluid flow, suspended particles always move in an erratic manner. This motion affects the dispersion of the suspended fibers in an unpredictable way. Reproducibility of dispersion may be expected only if the fluid motion producing dispersion is itself reasonably controllable. Any factor affecting fiber settling, for example, density, has an appreciable influence on the result.

A dynamic method of measurement, which allows the fibers to be acted upon by a continuous but constant and controllable agitation and which permits observation of flocculation under flow conditions, is much more desirable. One type of dynamic tester, a continuous blue glass view plate such as is used in many groundwood mills, is easy to fabricate. It has a thin film, low-velocity type flow which we considered undesirable for this study. Another type of dynamic tester, and the one adopted for this work, is a type originated by John Wollwage (*1*) of Kimberley Clark Corp. This tester consists of a large glass tube mounted vertically. Pulp suspensions flow downward through it.

D. E. BEASLY, Crown Zellerbach Corp., West Linn, Ore.

A consideration of Reynolds number indicates that for a 3-in. smooth-walled tube a flow rate of 7.5 liters per min. is the maximum for streamline flow. In this experiment a rate well within the laminar flow range, 4.6 liters per min., was used. At this lower rate, pulps with both high and low flocculation tendencies flocculate within the limits of the tube.

In constructing the flocculation tester for this experiment several modifications of the original Wollwage equipment were made. These include:

1. A small headbox, capacity 18 liters, with an overflow maintaining a constant head.
2. A retention tank to hold an excess of the pulp suspension.
3. A long fluorescent light source mounted directly behind the tube to provide better illumination.
4. A means of introducing air into the suspension and a method for removing air.

The following variables were studied in the modified Wollwage tester. (1) consistency; (2) temperature; (3) hydrogen ion concentration; (4) refining action; (5) pulping method and species; (6) chemical additives: (a) alum (b) surface-active agents (c) sodium hexametaphosphate (d) colloidal agents; and (7) air in stock.

EXPERIMENTAL

The procedure adopted for making a flocculation run consisted of the following steps.

1. Filtered water, pH 6.7 to 6.8, was used to dilute 7.5 grams (moisture-free) of fiber to 0.01% consistency. This consistency was determined by trial to give the best contrast for both viewing and photographing the fiber flocculation effects.
2. The agitators and the pump were started. The headbox was filled to the overflow. Before any measurements were made, the suspension was allowed to circulate through the apparatus for 30 min. This precaution was necessary because of fluctuations in flocculation which disappeared within 30 min. of start-up.
3. Temperature of the system was adjusted during the preliminary run-in period. A heating element and a cooling coil were provided in the retention tank to control temperature.
4. Temperature and pH were taken.
5. Flow rate through the tube was adjusted to 4.6 liters per min.
6. A photograph of the tube and a visual reading of the point at which flocculation first occurred were made.
7. Additives, if any, were introduced at this point. An interval of 10 min. was allowed after each addition to insure thorough mixing prior to taking subsequent photographs and readings.

Photographic Record

The flocculation tester was constructed so that it could easily be photographed. Preliminary considerations had indicated that a photograph of the tubes would: (1) provide a permanent indisputable record, and (2) assist in evaluation of various runs.

In the photographs, two things concerning the floc are noticeable. First, there is a point in the tube at which flocculation takes place. Above this point there is no appreciable flocing. Below, flocculation is general. Second, a change of character or size of the floc itself is seen when photographs of several runs are compared. From the standpoint of paper-

making, the size of floc formed may be of considerable importance. For the purpose of this study, however, only the distance down the tube at which flocculation first occurs is used as a criterion of flocculation.

Evaluation

A visual reading of the point at which a suspension flocculates is recorded in terms of distance below a fixed reference point. There is a straight line relationship between distance down the column and the time required for a given fiber to flow the same distance. It is believed that in many cases a time measurement is preferable. The results, therefore, are expressed to show any change in time of flow due to a change in conditions.

RESULTS

Consistency

Increasing consistency proportionately increased the number of fiber-fiber collisions and thus increased the flocculation tendency. The range of consistency from 0.002 to 0.05% was investigated. Lower or higher consistencies were difficult to evaluate because of lowered contrast in the tube.

Temperature

The effect of increasing temperature is a decrease in the viscosity of a fluid system. The result of a viscosity decrease is a decrease in the shearing force present in a laminar flow pattern. There is then less force tending to shear apart the clots of fiber. A decrease in temperature of 20°F., from 87 to 67°, increased the time to flocculation by 35 sec.

Hydrogen Ion Concentration

Book groundwood and bleached sulphite were used in exploring the pH effect of flocculation. pH variation itself, within the range normally encountered in machine systems, had no effect on flocculation.

Refining Action

As the freeness of a stock is lower by beating, the flocculation tendency increases.

As more fibrils are brushed out of the fiber surface there is a greater tendency for fibers to form clots as they collide. At the same time, more shearing force is required to separate the entangled fibers. The flocculation tendency, therefore, is proportional to degree of fibrillation.

Wood Species or Pulping Treatment

Tendency to flocculate appeared to be almost directly proportional to fiber length. The pulps tested are listed in order of decreasing flocculation tendency: (1) bleached kraft (50% Douglas-fir and 50% hemlock), (2) unbleached sulphite (hemlock), (3) bleached sulphite (hemlock), and (4) book grade groundwood (50% hemlock, 25% white fir, 25% spruce).

Chemical Additives

Alum. The addition of alum to a pulp suspension in filtered water, pH 6.8, sufficient to lower the pH to 6.6 sharply increased flocculation. The effect of further additions of alum was to disperse or retard flocculation. In the pH range of 6.3 to 4.6 the addition of alum to bleached sulphite increased the time to flocculation by 17 sec. Both of these observations are in agreement with those of Wollwage and Erspamer (*2*). The increased flocculation which occurred when alum was first added was due to an isoelectric condition brought about by reducing the negative charge on the fiber. Dispersion, which occurred as more alum was added, was in part due to a positive charge being imparted to the fibers by the positively charged alumina floc. It is believed that alum increased the hydration film and thereby reduced the flocculation tendency.

Surface-Active Agents. In order to determine whether surface-active materials cause changes in surface tension forces at fiber-fluid interfaces, and thus affect fiber flocculation characteristics, the following surface activities were investigated: (1) nonionic, (2) cationic, and (3) anionic. There was no discernible effect from the use of any of the agents used.

Sodium Hexametaphosphate. Sodium hexametaphosphate did not effect the flocculation characteristics of bleached sulphite. At concentrations in the range (0 to 0.005 *N*), there was no measurable improvement in the flocculation tendency. Cohen (*3*) reported a definite benefit from the use of the metaphosphate in conjunction with a refining treatment of the pulp. It was assumed that some refining treatment of the pulp was required before any improvement could be realized from the use of the metaphosphate.

Colloidal Agents. Slight concentrations of mannogalactan, in the range 0 to 0.5%, based on the dry fiber, decreased the flocculation tendency of bleached sulphite fiber. The addition of 0.2% mannogalactan increased the time to flocculation by 18 sec. Considering the concentration involved, it is believed that the effect is not a result of viscosity modification. The colloidal gum must reduce the electrokinetic charge on the fibers and enable them to be more easily dispersed in a flowing fluid.

Air in Stock

The reduction of air content from 0.15 to 0.05% increased the time to flocculation by 7 sec.

Compressed air was introduced into the stock through a ceramic diffuser. The factor which limited the concentration of air was the consistency of the pulp suspension. Entrained air must have fibers on which to impinge. Thus, at low consistency the flocculation tube will exhibit a flotation effect if too much air is introduced.

Removal of air was accomplished through the use of an aspirator and a centrifugal jet pump. The pulp suspension was drawn from the retention tank by the aspirator and sprayed into a standpipe which was connected to the suction side of the pump. The effect of this leg on the suction side of the pump was to aid in attaining 27 in. Hg of vacuum.

SUMMARY

The following variables affect the flocculation tendency: (1) consistency, (2) temperature, (3) refining action, (4) fiber length, (5) alum, (6) mannogalactan, and (7) air.

The following variables exhibit no effect on the flocculation tendency: (1) surface-active agents, (2) sodium hexametaphosphate, and (3) hydrogen ion concentration.

Of the several variables investigated, consistency and temperature had the greatest effect on flocculation. Of the chemical additives employed, alum and mannogalactan were the most effective in inhibiting flocculation. These additives, while having measurable value in improving formation, were only half as effective as a reduction in temperature of 20°F.

Equipment, similar to that used in this investigation, can be constructed at moderate expense. Once constructed, this tester can be used for preliminary evaluation of additives and variables in a screening step prior to machine trials. The expense of machine trials aimed at improving formation can therefore be kept to a minimum.

LITERATURE CITED

1. Wollwage, John C., *Paper Trade J.* 108, No. 12: 41–48; No. 13: 25–34 (March 23, 30, 1939).
2. Erspamer, August, *Paper Trade J.* 110, No. 24: 33–38 (June 13, 1940).
3. Cohen, W. E., Farrant, Gwenneth, and Watson, A. J., *Paper Trade J.* 132, No. 25: 19–30; 133, No. 4: 16–22 (June 22, July 27, 1951).

Credit is given to James Gingrich, a summer employee at West Linn, for much of the initial work on this project.

Pulp Mill Process Water from a Salt Contaminated River

ANDREW A. BROZ

Among the major considerations which must be met early in the conception of a new pulp mill is the problem of obtaining suitable process water. Such a problem was faced in planning the Weyerhaeuser kraft mill now under construction in Everett, Wash.

A proposal to purchase city water received a negative response from the city council since the additional demand could not be supplied without major expansion of existing facilities. Also considered as a possible source of supply was the Stilliguamish River. Water from this source would have to be pumped through 14 miles of pipe line to the mill site.

Economically, the most logical choice was the Snohomish River since the new kraft mill is located on its banks about a mile upstream from its mouth. Mill planners were reasonably sure that suitable water could be found in the Snohomish.

The Snohomish River empties into Port Gardner Bay through three separate channels. These are known as the Main Channel, Steamboat Slough, and Ebey Slough. Seven miles above the Main Channel mouth 10% of the total flow is diverted into Ebey Slough. Four miles below this junction 60% of the total flow splits off into Steamboat Slough with the remaining 30% carried by the Main Channel. The lower reaches of the Snohomish River system are affected by tidal action. At high tide salt water backs into the river's channels and moves upstream. The salt concentration is a function of tidal elevation, river flow, and the general topography of the area.

There were no recorded data with which to gage the salt-fresh water distribution with respect to distance, concentration, and time. To evaluate these factors a survey of river water conditions was begun in September, 1951. A survey (*1*) conducted by the TAPPI Water Committee advises that the presence of chlorides in kraft mill process water tends to promote corrosion difficulties in the manufacturing system and recommends a maximum allowable tolerance of 75 p.p.m. The chloride content of Port Gardner Bay water fluctuates with river flow. It averages about 16,000 p.p.m.

Once a week river water was analyzed for chlorides. Arbitrarily establishing a reference point of zero mile at the mouth of the Main Channel, samples were taken 1 mile upstream near the kraft mill site, 6 miles upstream at the town of Lowell, and 12 miles upstream at the town of Snohomish. Mill site samples, taken at high tide, showed chlorides ranging from 12,700 to 14,500 p.p.m.—practically undiluted bay water. A profile obtained at this site showed that undesirable chloride conditions may last as long as 10 hr. per tidal cycle. Since an average tidal cycle lasts about 12 hr., it was apparant that salt-free periods would be of short duration and that the intake should be located further upstream.

No salt was found in the samples taken at Snohomish. Economic considerations demanded an investigation of river water quality downstream from Snohomish with the objective of finding the optimum location which would satisfy both quality and economic requirements. Theoretically this would place the intake near the upper limit of salt water infiltration, the exact location of which depends upon river flow and tidal elevation.

Samples taken at Lowell during a period of low river flow averaging 1200 c.f.s. had chloride concentrations ranging from 250 to 700 p.p.m. At the same time it was observed that the direction of flow reversed on the flood tide carrying upstream considerable quantities of foreign material. During periods of higher runoff the flow did not reverse and no salt was found. These observations influenced the decision to abandon a proposed intake site in this area for one about a mile upstream in and near the head of Ebey Slough.

Weekly sampling continued at Lowell primarily for the purpose of identifying those critical conditions when river water in Ebey Slough could conceivably contain salt and should be analyzed. Approximately once a month a complete mineral analysis was made. The range of these results is given in Table I. No salt was found until late Summer of 1952 when low river flows of the previous year began to appear again. A profile of chloride concentrations obtained at this time showed a maximum of 215 p.p.m. about 1 hr. after high tide in Port Gardner Bay and indicated that salt conditions prevailed about 4 hr. per tidal cycle.

Table I. Analysis of Snohomish River Water at Lowell

Constituent	*Range, p.p.m.*
Total solids	33– 106
Organic plus volatile matter	10– 65
Mineral matter as sulphates	22– 63
SiO_2	16– 47
R_2O_3	0.5– 5
CaO	3– 7
MgO	1– 4
Sulphates	6– 12
Copper	0.01–0.017
Manganese	0.01– 0.04
Turbidity	15– 70
Color	10– 45
Chlorides	0– 700

The scene of the problem then shifted to Ebey Slough. River runoff records show that the flow during this period averaged 1310 c.f.s. With this flow no salt reached the site at tide elevations less than 10 ft. Maximum concentrations of 7 and 43 p.p.m. occurred on tides of 10.5 and 13.2 ft., respectively. A profile taken through the peak of the 10.5 ft. tide showed salt to be present for about 2 hr. with the maximum concentration appearing 3 hr. after high tide in the bay. These results are given in Table II. A profile taken just outside the slough in the Main Channel during the large 13.2-ft. tide indicates the maximum contamination period at the intake will be from 2 to 3 hr.

Table II. Chlorides at Ebey Slough on Sept. 25, 1952 (High Tide in Port Gardner Bay = 10.5 Ft. at 10:46 a.m.)

Time	*Parts, per million*
12:30 p.m.	0
12:45	2.5
1:00	3.5
1:15	3.5
1:30	7.0
1:45	7.5
2:00	7.5
2:15	5.5
2:30	3.5
2:45	1.5
2:55	0

This survey also revealed that salt water does not reach the site via the Ebey Slough canal even though the direction of flow reversed on the flood tide. Apparently the slough's 16 miles of winding watercourse is an effective barrier to such deep penetration. The salt water comes up the Main Channel and just outside the slough a maximum chloride concentration of 170 p.p.m. was recorded. When the ebb begins a portion of this salt-fresh water reservoir feeds into the slough and by the time it reaches the intended intake site 600 yd. downstream further dilution reduces the chloride concentration by about 75%. Occasionally considerable sur-

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face debris is channeled into the slough but bottom samples are clear.

A survey of the horizontal distribution of salt and fresh water in the Main Channel was made from Steamboat Slough to Ebey Slough during a river flow of 1300 c.f.s. The sampling was timed to coincide with the maximum effect of a 13-ft. tide. The primary objective of this survey was to determine the maximum distance salt water moves upstream. The results, given in Table III, show that deepest penetration with the above conditions occurs about 0.5 mile beyond Ebey Slough.

Ketchum (*2*) has presented an empirical theory which can be used to calculate the average distribution of fresh and salt water in an estuary. These calculations can be made without undertaking field work since existing data found in tide tables, navigation charts, and hydrographic records are used. Using the mean tidal range as a basis, the changes in salinity to be expected with different river flows can be calculated.

The theory has been applied to the Snohomish River using a mean tidal range of 7.4 ft. and a river flow of 1300 c.f.s. A comparison of the calculated distribution with the observed conditions is given in Fig. 2. The calculated distribution shows that between Ebey Slough and Lowell the influence of fresh water predominates. The opposite is true from Preston Point to Steamboat Slough. Between these two sections

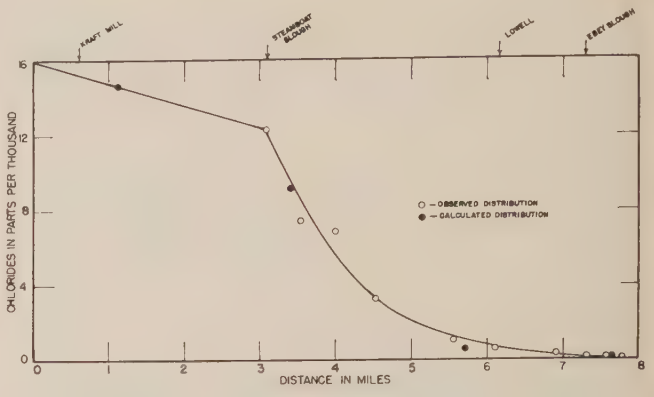


Fig. 2. Observed and calculated distribution of chlorides in the main channel of the Snohomish River

maximum transition occurs. Steamboat Slough, with its greater volume, undoubtedly has an immediate dilution effect on the more saline water coming up the Main Channel. This agrees with survey data which shows a sharp drop in salinity between Steamboat Slough and Lowell. Normally the distribution pattern would be expected to be an "S" shaped curve but it is distorted by the fact that the capacity of Steamboat Slough is approximately twice that of the Main Channel.

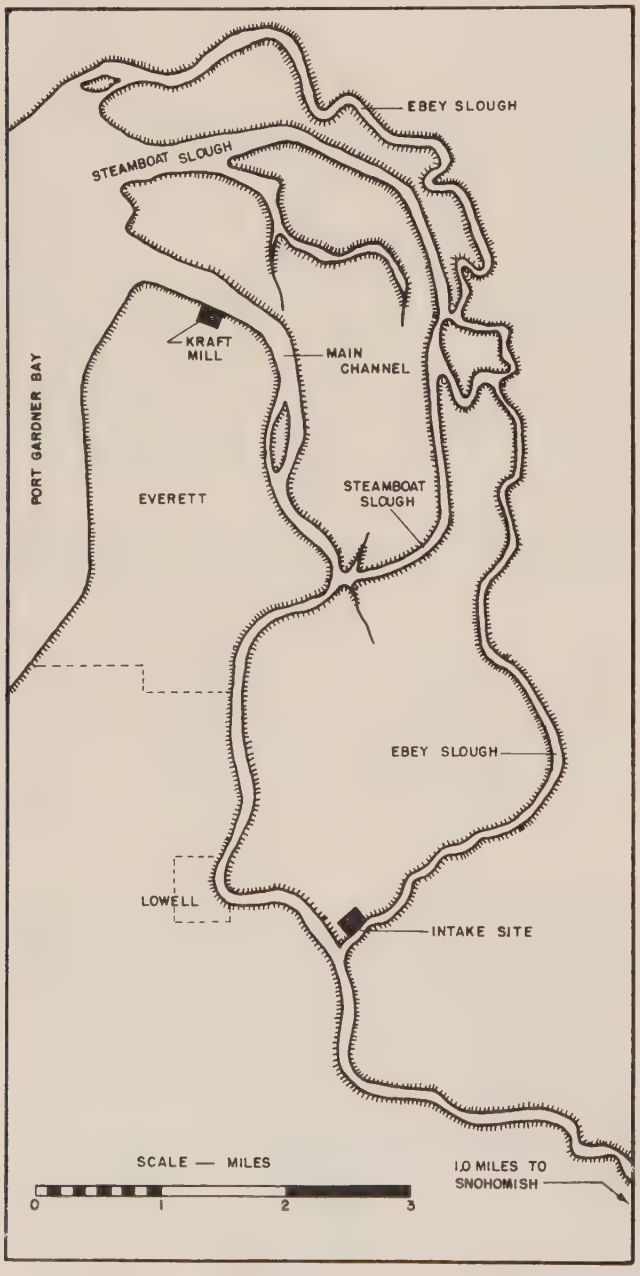


Fig. 1. The Snohomish River Estuary

Table III. Chloride Distribution from Steamboat Slough to Ebey Slough on Sept. 3, 1952 (High Tide in Port Gardner Bay = 13.0 Ft. at 5:52 p.m.)

Miles upstream from Steamboat Slough	*Time, p.m.*	*Parts per million*
0.00	6:05	12,300
0.45	6:15	7,400
0.90	6:25	6,800
1.43	6:30	3,200
2.45	6:40	1,040
3.00	6:50	580
3.80	7:05	310
4.20	7:15	125
4.45	7:25	90
4.65	7:30	32

Both the observed and calculated results place the position of maximum salt penetration about 0.5 mile above Ebey Slough. Since there appears to be good agreement between survey and calculated data, the theory was used to calculate the lower limit of river flow above which no salt would reach Ebey Slough. A conservative approach results in a river flow of 1900 c.f.s. which would place maximum salt penetration at Lowell, about a mile downstream from Ebey Slough. River flow records show that normal runoff will exceed this minimum flow in all months except August and September. Tide tables show that during these two months there will be about 30 tides with elevations greater than 10 ft.

Thus, under normal conditions, water from Ebey Slough should be salt free except for 30 days of the year. The contamination period should not be more than 3 hr. on any day and the maximum chloride concentration should not exceed 50 p.p.m. This is well within the tolerances advised by TAPPI and should not present a problem.

LITERATURE CITED

1. Miller, Lewis B., *Tech. Assoc. Papers* 29: 417–418 (1946).
2. Ketchum, B. H., *J. Marine Res.* 10, No. 1: 18–37 (June 30, 1951).

Microbiological Control Studies—Evaluation of a New Biocide

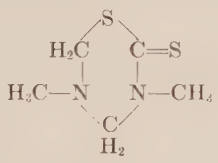
R. J. HERSCHLER

THE growth of microorganisms, commonly termed slimes, is a problem of varying magnitude throughout the pulp and paper industry. Many chemicals have been proposed the past two decades as slimicides, few have survived the test of time.

The more common chemicals used at the present time by the pulp and paper industry to control microbiological growth are the organic mercurials, chlorine, and chlorinated products, particularly the polychlorophenates. These classes of chemicals have dominated the market as slime control agents for many years without a successful challenge. Their performance has not been entirely satisfactory, for they all possess properties that limit their use. Some impart medicinal odors to paper, others affect pulp color, are corrosive, very toxic, or cause foam.

The problems associated with microbiological control have become more complex yearly. There is a need for biocides to lengthen felt life, for insoluble biostatic films to coat contact surfaces of pipes, troughs, and chests carrying and holding pulp and white water. Within the industry, large quantities of starches and proteins are used, and a more effective preservation would be desirable. A particular need is for an odorless, tasteless, colorless chemical toxicant that will retard or eliminate the growth of slime forming and associated organisms found in the white water of pulp and paper mill systems.

A new chemical biocide has been evaluated in the laboratory, mill tested, and shown to be suitable for use as a pulp and paper mill slime control agent. This biocide possesses many desirable properties not available in the commercial slimicides of today. This compound is 3,5-dimethyltetrahydro-1,3,5,2H-thiadiazine-2-thione and has the structure:



For the purposes of reference the name will be shortened in this text to 35-D.

SYNTHESIS OF 35-D

The preparation of 35-D was first described by Marcel Delepine (*1*) under the subject heading "Action of carbon disulphide on trimethyltrimethylenetriamine." The procedure is relatively simple, the yield is good, and the basic materials inexpensive. The product was called by Delepine "Dimethylformocarbothiadine." It was later proved by Ainley (*2*), *et al.*, to have a structure corresponding to 1,3,5,2-tetrahydro-3,5-dimethylthiadiazine-2-thione. The preparation of the intermediate trimethyltrimethylenetriamine is given in Beilstein (*3*), and consists merely of mixing methylamine and formaldehyde together, then dehydrating with salts.

DISCUSSION OF THE LABORATORY EVALUATION

Our study of 35-D as a slime control chemical employed basically the pulp substrate method developed and described by G. D. King (*4*). This test method requires but minimum equipment and reproducible results are obtained. With results derived from this test method it is possible to predict accurately the degree of success of a slimicide before mill trial,

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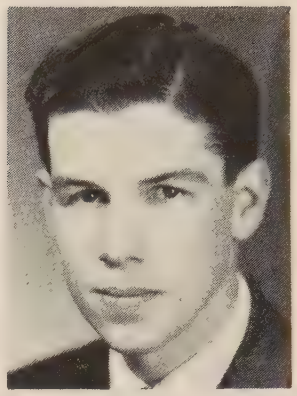


R. J. Herschler, Crown Zellerbach Corp.

provided the natural microflora which the pulp slurry contains are not altered or substituted.

In the first evaluation, 35-D was compared to 2-methoxy-1,4-naphthoquinone. The results are tabulated below:

Table I. 35-D Compared to 2-Methoxy-1,4-Naphthoquinone

Chemical concn., p.p.m.	*Chemical*	*Total count*	*Reduction in count, %*
0	35-D	2,250,000	...
20	35-D	0	100
40	35-D	0	100
80	35-D	0	100
100	35-D	0	100
200	35-D	0	100
0	2-methoxy-1,4-naphthoquinone	2,250,000	...
20	2-methoxy-1,4-naphthoquinone	807,000	64.0
40	2-methoxy-1,4-naphthoquinone	777,000	65.0
80	2-methoxy-1,4-naphthoquinone	622,000	72.4
100	2-methoxy-1,4-naphthoquinone	367,000	83.7
200	2-methoxy-1,4-naphthoquinone	297,000	86.7

Notes: (1) Treatment time (time from addition of slimicide to plating)—24 hr. (2) Plates counted after 48 hr. incubation. (3) Agar media—nutrient (Difco). (4) 0.5% consistency groundwood used as substrate. (5) Incubation temperature—37°C.

To achieve a 100% reduction in count at 20 p.p.m. indicates that a chemical is a very potent slimicide. These results of Table I indicated that a biocide approaching the effectiveness of organic mercurials may have been found. Further evaluation studies were immediately started.

Succeeding evaluations compared it to a 10% commercial solution of phenylmercuricacetate and a composite commercial slimicide composed of 10% phenylmercuric acetate with 50% solids of a polychlorophenate carried in suitable water miscible solvents. The results will be found in Tables II and III below:

Reviewing the performance of 35-D in Tables I, II, and III, a reduction of total slime count of better than 90% was achieved in all testing at 20 p.p.m. the findings reported in these tables justified further study. The substrate was changed from groundwood to ammonia-base sulphite white water at headbox consistency. The results of this testing will be found in Table IV.

Table II. 35-D Compared to Phenylmercuric Acetate Solution 10%

Chemical concn., p.p.m.	Chemical	Total count	Reduction of count, %
0	35-D	1,200,000	...
2	35-D	441,000	63.2
10	35-D	129,000	89.3
20	35-D	81,000	93.2
40	35-D	20,000	98.3
80	35-D	0	100.0
0	PMA 10%	1,200,000	...
6	PMA 10%	80,000	93.3
30	PMA 10%	97,000	91.9
60	PMA 10%	57,000	95.3
120	PMA 10%	229	99.8
240	PMA 10%	0	100.0

Notes: (1) Treatment time—24 hr. (2) Plates counted after 48 hr. incubation. (3) Agar media—nutrient (Difco). (4) 0.5% consistency groundwood used as substrate. (5) Incubation temperature —37°C.

The biocide 35-D was next considered for a mill trial. Before the trial, however, it was desirable to determine or at least predict the best rate of addition and the most desirable length of contact of the slimicide with the pulp. The following test data presented as Table V assisted in making these predictions.

Table III. 35-D Compared to Composite Slimicide

Chemical concn., p.p.m.	Chemical	Total count	Reduction of count, %
0	35-D	900,000	.....
5	35-D	451,000	50
10	35-D	107,500	88
20	35-D	27	100 (−)
40	35-D	0	100
0	Composite slimicide	900,000	.....
5	Composite slimicide	903,000	0 (−)
10	Composite slimicide	472,000	47.2
20	Composite slimicide	343,000	61.8
40	Composite slimicide	274,200	69.8

Notes: (1) Treatment time—24 hr. (2) Plates counted after 48 hr. incubation. (3) Agar media—nutrient plus Sabourauds dextrose (Difco). (4) 0.5% consistency groundwood used as substrate. (5) Incubation temperature—37°C. (6) Composite slimicide—10% phenylmercuric acetate plus 50% polychlorophenates in 40% solvents.

From examination of the data in Table V, the following information was obtained:

1. The lag from time of addition of 35-D to time of maximum kill was greater than 24 hr.
2. The composite slimicide killed rapidly but its activity was lost in a short time through sorption with the pulp.
3. 35-D was an active slimicide even after 2 months in solution indicating little sorption with the stock (affinity).
4. If the affinity for fiber was low or nil and the slimicidal potency was evident for months in solution in a pulp slurry then losses would be small and due to: (1) entrainment in the paper web, (2) white water not recirculated but sent to the sewer.

Using the information derived from an analysis of the data of Table V the following specifications were set up to serve as the guide to proper use of 35-D in a mill trial:

1. At the start-up of a treatment, a high level of toxicant should be maintained for 48 to 72 hr. to build up and maintain a lethal concentration.
2. Additional amounts of the slimicide should be fed continuously to the system to maintain biostasis. The quantity of added toxicant would depend on the rate of loss of toxicant.
3. The 35-D should be added to the stock at a point providing for maximum contact time (i.e., as far back in the system as is feasible).
4. Close the white water system if possible to reduce slimicide losses to the sewer.

Table IV. 35-D Evaluated Using Ammonia-Base White Water Substrate

Chemical concn., p.p.m.	Chemical	Total count	Reduction of count, %
0	35-D	180,000	.....
2	35-D	40,500	77.5
10	35-D	27,420	84.5
20	35-D	103	100 (−)
40	35-D	2	100
80	35-D	0	100

Notes: (1) Treatment time—24 hr. (2) Plates counted after 48 hr. incubation. (3) Agar media—nutrient (Difco). (4) 0.3% consistency sulphite used as substrate. (5) Incubation temperature—37°C.

Actually, during the mill trials to be discussed, 35-D was added by the following methods:

1. By slug dosage—adding all toxicant used per 24 hr. in 3 hr.
2. By intermittent feeding—adding all toxicant used per 24 hr. in three to six 1-hr. feeding cycles.
3. By continuously feeding the slimicide to the system so that the concentration in the white water was maintained at a constant biostatic level at all times.

Method 3, continuous feeding, consistently afforded the best results and was adopted as standard practice. Comparative data substantiating the belief in the superiority of the continuous addition of 35-D are presented below. A slime measuring unit (*5*) which measures the growth of slime on a wooden panel was employed to establish the effectiveness of each method.

Length of treatment, days	Treatment per 24 hr.	Average slime panel reading, g./24 hr.
11	65 lb. of slimicide X added in 2 1/2 hr. at the fan pump	26.2
7	10 lb. of 35-D in each of three successive mixing chests (30 lb. total per day)	31.4
9	65 lb. of slimicide X added in 2 1/2 hr. at fan pump	28.6
6	30 lb. of 35-D added by continuous feeding to the mixing chest	16.8

During this series of tests the furnish to the paper machine was the same. Slimicide X designates a commercial slimicide containing at least 10% phenylmercuric acetate. It was likewise found during mill trials that better results were obtained if 35-D was added at or near the beater rather than at the machine fan pump. This of course permitted longer contact time of the slimicide with the pulp.

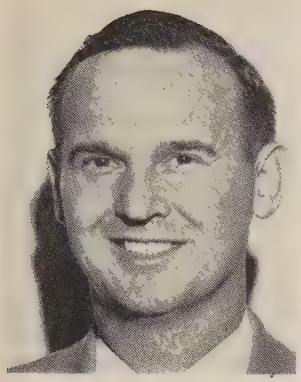
The suspected low substantivity of 35-D for fiber needed to be confirmed. A test was devised to measure a slimicide's affinity for the pulp substrate. The procedure of the test method was as follows:

1. Select a reactive pulp as groundwood (50 grams moisture-free weight) (groundwood pulp was used because it exhibits highest sorption for slimicides).
2. Slurry pulp then draw off excess water on a Buchner funnel.
3. Reslurry the pulp pad in a specific concentration (50 p.p.m.) of test slimicide dissolved in 1000 ml. of water.
4. Allow 24 hr. contact time for the slimicide solution with the pulp (providing agitation).

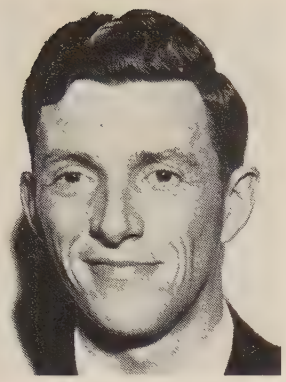
Table V. Relation of Numerical Slime Count to Time

Chemical	Time 0	5 min.	10 min.	30 min.	1 hr.	2 hr.	24 hr.	48 hr.	14 days	28 days	66 days
35-D	1,432,000	340,000	307,000	150,000	139,000	88,500	571	0	0	0	0
Composite slimicide	1,432,000	91,000	48,000	14,400	7,300	11,900	18,300	182,000	1,006,000	807,000	..

Notes: (1) Treatment level—50 p.p.m. (2) Agar medium—nutrient/Sabourauds dextrose (Difco). (3) Plates counted after 48 hr. incubation. (4) 0.7% consistency groundwood used as substrate. (5) Incubation temperature—37°C. (6) Treatment time as indicated. (7) Composite slimicide—10% phenylmercuric acetate plus 50% polychlorophenates in water miscible solvents.



A. A. Broz, Weyerhaeuser Timber Co.



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5. Extract the liquid on a Buchner saving the filtrate which should be 1000 ml. ±5.
6. Test the filtrate for biocidal potency, running simultaneously as a check, a freshly prepared solution of the slimicide made up to 50 p.p.m. in water. The difference in potency between the two solutions due to the test slimicide's affinity for fiber may be expressed as a percentage value.

This test method has undeniable shortcomings since one cannot differentiate loss by entrainment and decomposition in solution from affinity. Entrainment may represent less than 10% error, however, the rate of decomposition of a solution of a slimicide is easily determined by a separate test. 35-D has an affinity of 34% as established by the test method. If chlorine, polychlorophenates, or quaternary ammonium complexes are tested for fiber affinity by this method the loss in slimicidal power approaches 100%.

DISCUSSION OF MILL TRIALS

Sufficient laboratory data were available to warrant a mill trial. 35-D was first used in a groundwood mill. The initial treatment level was about $^1/_2$ lb. per ton of air-dry pulp added continuously at a point near the grinders. The system was noticeably cleaner after 2 days' treatment and within 2 weeks was virtually rid of slime accretion. One difficulty was encountered the second day of the trial. Heavy slime growths had gathered in blind spots and pipes throughout the system and sloughed off accumulating in the decker backwash. Workmen removed several wheelbarrow loads of loosened slime. This trial was 45 days in length and control was maintained at $^1/_6$ lb. per ton the last 10 days of trial. The trial was analyzed on a cost/efficiency basis and termed a success.

The supply of 35-D for mill trials has been limited thus far. All the chemical used for mill trials came from a pilot plant. Nevertheless several tons of 35-D have been used on five paper machines located in three mills making different grades of paper. The pilot-plant price has been much higher than the expected price of the commercial product. Despite this, all mill trials when analyzed on a cost/efficiency basis (using the pilot-plant price) were termed successful although comparison was made to the most effective commercial slimicides now available. There is a history of good control at a treatment level of $^1/_2$ lb. per ton or less for all machines. Thus far, there have been no mill trial failures.

The efficiency of 35-D or any other slime control chemical is judged three ways: (1) record of machine performance and appearance of machine during shutdowns, (2) slime board readings, and (3) microbiological counts made on white water samples.

When 35-D was used on a machine the dirt count dropped, slime growth on the slime boards diminished as did the slime organism counts, and paper machines were much cleaner when examined at shutdowns.

GENERAL DISCUSSION

35-D is presently supplied in powder form and is relatively insoluble in water. Because large volumes of water are required to solubilize 35-D, it has been added to the various mill systems principally in powder form. Automatic feeding equipment would greatly simplify its practical use.

The approximate solubility of 35-D in various solvents at 25°C. follows:

Solvent	*Approximate solubility, g./100 ml.*
Trichloroethylene	30
Ethylene dichloride	20
Acetone	19
Cyclohexanone	10
Ethanol	2
Xylene	1–2
Water	0.1

35-D may be a suitable slimicide for use during the manufacture of food papers, however, before such a use is made of the chemical, additional data are required regarding toxicity and residues in the sheet. The research required will probably be done eventually by the chemical companies manufacturing the product.

It is known that the single oral dose LD_{50} to rats is 0.5 gram per kilogram which makes it comparable roughly to borax. The dry crystals do not penetrate the skin and have been safely handled without gloves. A respiratory mask is recommended where there is the possibility of long exposure to 35-D dust. Some persons may be sensitized to the chemical and should avoid direct contact.

It was previously stated that 35-D was not corrosive to the metals and their alloys used commonly by the pulp and paper industry. The use of 35-D, however, will cause the formation of a black coating on a fourdrinier wire. Wire life has not been shortened, in fact, probably it is only accidental but the average wire life was extended during several mill trials. The black coating or film cast on bronze and brass fourdrinier wires is of minimum thickness and does not impair drainage.

However, the reaction product of phenylmercuric acetate and 35-D does cause corrosion. An aqueous solution of 35-D and phenylmercuric acetate forms a very insoluble precipitate. The biocidal activity of each is reduced. The resultant slimicidal potency of a mixture of 50 p.p.m. 35-D and 50 p.p.m. of 30% phenylmercuric acetate solution is less than either chemical alone. During mill trials it was found that the insoluble complex formed by the reaction of 35-D with phenylmercuric acetate was very corrosive to brass, bronze, and possibly copper. Although a very low concentration of mercurial was present, the wire life, for example, was cut in half. The corrosion was readily evident as deep pitting when wires were examined under the microscope. The use of mercurials with 35-D is to be avoided.

Only brief mention will be made of studies of 35-D as a preservative of starches and proteins. There have been no mill trials. Work has been limited to laboratory studies which showed 35-D to be superior to a 30% solution of phenylmercuric acetate.

In the discussion of results of Table V it was stated that 35-D maintained the sterility of a pulp slurry for 66 days. Actually we believe the functioning biocide was not 35-D but a transformation product as yet unidentified. This belief is based on the knowledge that an aqueous solution of 35-D will precipitate from the solution slowly after 24 hr. standing at room temperature. The precipitate, although it is biocidic, does not resemble 35-D closely.

35-D was mill evaluated as a preservative of wet lapped pulp. It did not prove successful. This was surprising considering the long period of time a slurry of pulp will remain

sterile when 50 p.p.m. of toxicant is added (seen in Table V). Perhaps the technique was at fault.

SUMMARY AND CONCLUSIONS

1. 35-D through laboratory testing and mill trial was shown to be a potent slimicide. It is effective at low concentrations, being superior to polychlorophenates and comparable to approximately a 25% solution of phenylmercuric acetate on a weight basis.

2. The biocide possesses low toxicity to warm-blooded animals, is easily handled, and imparts no odor, off-color, or taste to pulp or paper.

3. The toxicant is prepared from low cost, readily available, chemicals. Furthermore, the yield of the product is good which means potentially a lowering of slime control costs.

4. 35-D exhibits low affinity for fiber, is not significantly corrosive to metals or alloys used by the pulp and paper industry, and is nonfoaming.

5. 35-D is characterized by a slow rate of kill in marked contrast to presently used chemicals. The compound is effective against bacteria and fungi (including yeasts)—no exceptionally resistant strains have thus far been found during laboratory testing or mill trial.

6. It is recommended that the toxicant 35-D be dispensed to a pulp mill or paper machine as follows: (a) initially at a high treatment level ($^1/_2$ to $^3/_4$ lb. per ton of air-dry pulp); (b) feed the toxicant by continuous addition, reducing the treatment level gradually until the minimum control level is reached; (c) feed the biocide at a point in the system allowing maximum contact time with the stock.

LITERATURE CITED

1. Delepine, M., *Bull. Societe Chemique* 15: 891–899 (1897).
2. Ainley, A. D., Davies, W. H., Gudgeon, H., Harland, J. C., and Sexton, W. A., *J. Chem. Soc.* 147–152 (1944); *C. A.* 38: 4265.
3. Beilstein, "Organische Chemie," 26: 1.
4. King, G. D., and Venables, J. V., *Pulp and Paper* 15, No. 1: 80, 82–85 (Jan., 1949).
5. "Bulletin 10 P," Appendix C, Buckman Laboratories, Inc., Memphis, Tenn.

The laboratory work herein reported was conducted at Crown Zellerbach Central Research Dept. The author is indebted to Walter F. Holzer and Chester T. Beals for their suggestions and assistance during the investigation.

Measurement of Dimensional Stability of Insulation Board

S. GORDON CRAIG

It is common knowledge to anyone familiar with wood and its properties that this material expands and contracts with changes in humidity conditions. Since this property is inherent in the wood itself, it is also manifested in such products as insulation board which uses wood as a raw material and presents an apparently insurmountable problem as far as complete control is concerned. There are, of course, methods which may be used to minimize this property of expansion and contraction with change in humidity. However, the evaluation of these methods and the determination of their relative effect on dimensional stability are dependent on an accurate and reproducible method of measurement.

Inasmuch as this undesirable property is a problem which confronts the whole wood fiber industry to a greater or lesser degree, then it would seem that a logical approach would be to pool the ideas and information accrued in the various laboratories so that a common attack could be made toward a solution. The general public and the wood fiber industry would both benefit by any methods which might be adopted to exercise closer control over this property. The author would like to suggest the formulation and standardization of an accurate and reproducible method of measuring dimensional stability of insulation board as a starting point for this sharing of ideas. As a contribution, the author would like to explain a method in use in this company's laboratory.

The standard test for the determination of linear expansion as given in Federal Specifications and Commercial Standard LLL-F-321b-9 has been found by experience to be inadequate and in need of revision; this specification describes the test as follows: "the maximum linear expansion shall be determined in the following manner from a specimen 3 by 12 in. that has been cut parallel with the board and from a like specimen cut at right angles thereto. At each of two points approximately 10 in. apart on the center line of each specimen a small area is coated by rubbing with a glass marking pencil (or wax crayon). A fine crossmark is made with a razor blade on the center line in each of these two areas as reference points for length measurements. The specimens are then conditioned for 24 hr. at 50% relative humidity and measurements are then made of the distance between the two reference points. A scale graduated in hundredths of an inch is used and readings are made with a magnifying lens to the nearest 0.005 in. The specimens are then conditioned for 24 hr. at 97% relative humidity after which the distance between the two reference points is again measured. The measurements shall be made in the conditioned air specified in each case or as quickly as possible as each specimen is removed therefrom. The linear expansion shall be reported as the increase in length between the reference points as a percentage of the length at 50% relative humidity."

PROBLEMS WITH PRESENT STANDARD METHOD

This test was used in the laboratory for some time but it was found to be unsatisfactory and entirely inadequate. It was found that it was rarely possible to duplicate results on determinations of dimensional stability. For instance, handsheets made from pulp which had been treated in a certain manner were tested for stability. When this treatment was duplicated and handsheets again made from the new pulp, it was found more often than otherwise that results on stability did not agree with those obtained from the first trial. Therefore, it was impossible to estimate the relative value of various treatments given the chips or pulp. Since the actual expansion of a specimen of insulation board 10 in. long is so small, the accuracy of this method is not sufficient to detect and define the small differences in expansion of various products. What is more important, it is not possible to detect the small differences within one product caused by various treatments to the raw material.

It has been found that, in general, various types of insulation board will expand 0.3 to 0.8% from a moisture-free condition to 15% moisture. These are the maximum limits and the average range of expansion over the same moisture range is probably closer to 0.4 to 0.6%. This represents a difference of only 0.040 to 0.060 in. in actual expansion which must be measured. This then is the limiting factor in the use of this method, because it is only possible to measure to the nearest 0.010 in. Another objection to the method was that various types of products will absorb moisture at various rates, and it was felt that the 24-hr. conditioning period was insufficient for some samples to come to equilibrium. As a result of these observations, the standard method was abandoned and a new method adopted which, though not perfect, has proved the merit of much greater accuracy and reproducibility.

S. Gordon Craig, Associate Chemical Engineer, Research Laboratory, Simpson Logging Co., Shelton, Wash.

DESCRIPTION OF NEW METHOD

The equipment required for the new method is as follows:

1. A suitable bench saw for cutting samples 3 by 10 in.
2. A circulating hot air oven operating at 250 to 300°F. to dry the samples.
3. One or more desiccators sufficiently large to contain a number of these samples.
4. An ordinary beam balance with a sensitivity of 0.1 gram.
5. An instrument using a dial micrometer with an accuracy of 0.001 in. (see Fig. 1).
6. A constant humidity cabinet with forced air circulation, fitted with open racks on which to suspend the samples. The samples must be staggered both vertically and horizontally in order to assure maximum and constant air circulation

Table IA. Data Obtained by Federal Specification LLL-F-321b-9 Test

	1	2	4	4	5
Sample E					
Weight, moisture-free	135.7	136.0	135.0	137.5	134.6
Length, moisture-free	9.98	9.99	9.98	9.97	9.98
Weight at 50% R.H.	140.1	140.0	140.6	140.9	140.0
Length R.H.	10.01	10.02	10.02	9.99	10.01
Weight at 97% R.H.	155.5	156.0	155.9	156.1	155.1
Length at 97% R.H.	10.04	10.05	10.04	10.02	10.03
Sample D					
Weight, moisture-free	144.8	143.5	146.0	139.8	143.1
Length, moisture-free	9.97	9.97	9.94	9.97	9.96
Weight at 50% R.H.	150.3	148.7	152.5	145.0	148.5
Length at 50% R.H.	10.00	10.01	9.98	10.02	9.98
Weight at 97% R.H.	165.9	163.5	168.6	159.5	163.1
Length at 97% R.H.	10.03	10.03	10.00	10.03	10.02
Sample A					
Weight, moisture-free	57.6	57.0	57.9	57.9	57.6
Length, moisture-free	9.94	9.93	9.95	9.93	9.95
Weight at 50% R.H.	62.0	61.4	62.1	62.3	61.9
Length at 50% R.H.	10.00	9.99	10.00	9.98	10.01
Weight at 97% R.H.	69.01	68.2	69.3	69.3	68.8
Length at 97% R.H.	10.02	10.01	10.03	10.00	10.03
Sample C					
Weight, moisture-free	78.1	77.3	77.1	77.3	77.5
Length, moisture-free	9.98	9.97	9.96	9.97	9.97
Weight at 50% R.H.	83.2	82.4	81.8	82.7	82.9
Length at 50% R.H.	10.01	10.00	10.00	10.00	10.00
Weight at 97% R.H.	92.3	91.5	90.3	91.4	91.8
Length at 97% R.H.	10.04	10.04	10.03	10.03	10.03
Sample B					
Weight, moisture-free	78.8	78.3	78.0	79.2	79.3
Length, moisture-free	9.96	9.96	9.98	9.98	9.96
Weight at 50% R.H.	84.3	83.7	83.4	84.8	85.0
Length at 50% R.H.	10.01	10.01	10.02	10.00	9.99
Weight at 97% R.H.	95.5	94.2	93.8	94.9	95.7
Length at 97% R.H.	10.04	10.04	10.05	10.03	10.03

Table IB. Calculations Obtained from Above Data

	1	2	3	4	5
Sample E					
Moisture at 50% R.H., %	3.3	2.9	4.1	2.5	4.0
Moisture at 97% R.H., %	14.6	14.7	15.4	13.5	15.2
Increase in length from 50 to 97% R.H.	0.03	0.03	0.02	0.03	0.02
Expansion, %	0.3	0.3	0.2	0.3	0.2
Av. moist. at 50% R.H.	3.4				
Av. moist. at 97% R.H.	14.7				
Av. expansion, %	0.3				
Sample D					
Moisture at 50% R.H., %	3.8	3.6	4.4	3.7	3.8
Moisture at 97% R.H., %	14.6	13.9	15.5	14.1	14.0
Increase in length from 50 to 97% R.H.	0.03	0.02	0.02	0.01	0.04
Expansion, %	0.3	0.2	0.2	0.1	0.4
Av. moist. at 50% R.H.	3.9				
Av. moist. at 97% R.H.	14.4				
Av. expansion, %	0.2				
Sample A					
Moisture at 50% R.H., %	7.6	7.7	7.3	7.6	7.5
Moisture at 97% R.H., %	19.8	19.6	19.7	19.7	19.5
Increase in length from 50 to 97% R.H.	0.02	0.02	0.02	0.03	0.02
Expansion, %	0.2	0.2	0.3	0.2	0.2
Av. moist. at 50% R.H.	7.5				
Av. moist. at 97% R.H.	19.7				
Av. expansion, %	0.2				
Sample C					
Moisture at 50% R.H., %	6.5	6.6	6.3	7.0	6.9
Moisture at 97% R.H., %	18.2	18.4	17.6	18.2	18.5
Increase in length from 50 to 97% R.H.	0.03	0.04	0.03	0.03	0.03
Expansion, %	0.3	0.4	0.3	0.3	0.3
Av. moist. at 50% R.H.	6.7				
Av. moist. at 97% R.H.	18.2				
Av. expansion, %	0.3				
Sample B					
Moisture at 50% R.H., %	7.0	6.9	6.9	7.1	7.2
Moisture at 97% R.H., %	21.2	20.3	20.3	19.8	20.1
Increase in length from 50 to 97% R.H.	0.03	0.03	0.03	0.03	0.04
Expansion, %	0.3	0.3	0.3	0.3	0.4
Av. moist. at 50% R.H.	7.0				
Av. moist. at 97% R.H.	20.3				
Av. expansion, %	0.3				

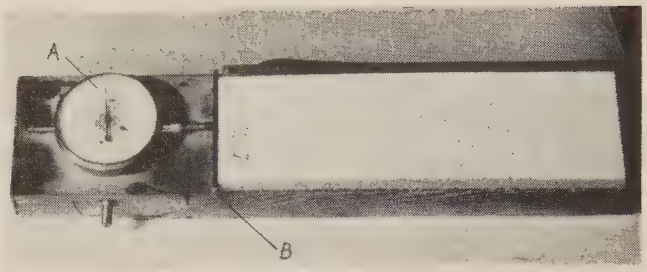

Fig. 1

A—Dial micrometer. B—Steel bar planed to uniform thickness.

around the sample. Samples which are moisture-free and suspended in an atmosphere of 90% R.H. will absorb from 13 to 18% moisture in 8 hr. (see Fig. 2).

PROCEDURE

The samples are cut to dimensions of 3 by 10 in. and after being dried to a moisture-free condition are placed in a desiccator to cool to room temperature. The use of a desiccator was found to be necessary because of the hydroscopic nature of hot dry wood. After cooling, the samples are removed from the desiccator and as rapidly as possible are weighed and measured for length. The samples are then suspended in the humidity cabinet and are removed at increasing intervals of time for weighing and measuring, and the last measurements are taken 24 hr. after starting. With these data it is possible to calculate the percentage moisture and percentage expansion at the various time intervals and thus determine expansion as a function of the absolute moisture content of the sample. Then by plotting expansion versus moisture expansion, curves of various samples may be drawn. In order to facilitate the comparison of expansion values, it was arbitrarily decided that the total expansion from 0 to 15% moisture be taken as a standard.

In order to compare the two methods, five samples were made from stock pulp in the laboratory. Sample A had a caliper of about $^3/_8$ in. and had a relatively high density. Samples B and C had a lower density but had a caliper closed to $^1/_2$ in. Samples D and E were processed from faster stock and each had a relatively low density and were 1 in. thick. It was intended that the resulting dimensional stabilities of these samples would have a fairly wide range so that a better comparison of the two methods would be made.

Data obtained by using the method of Federal Specifications and Commercial Standards are given below. There is also one sample set of data obtained by our method. Expansion curves as obtained by our method are shown in Fig. 3.

According to results obtained by the standard method of Federal Specifications, samples A and D expand 0.2%, while the other samples tested had expansions of 0.3%. Experience

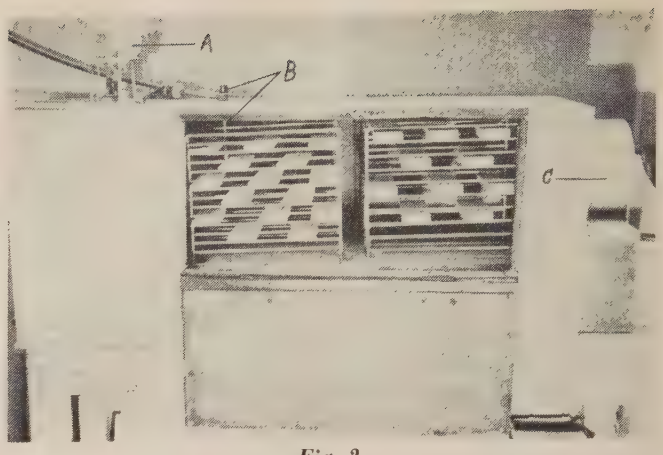

Fig. 2

A—Reservoir of water to maintain constant level in evaporator bowl inside cabinet. B—Thermostat to maintain constant temperature of water in evaporator bowl. C—Fan to circulate air through cabinet.

has shown that these results are for the most part meaningless because a high density board will certainly expand more than one which is low in density. Experience has also shown that expansion is a function of the thickness of the product and a thick board, e.g. 1 in., will have greater stability than the thinner board with other factors such as density being the same. An examination of the expansion curves indicates that which was suggested earlier in connection with the range of expansions encountered. If the expansions at a constant moisture content of 15% are determined from the curves, it is found that the expansions vary from 0.47 to 0.59%. This represents a difference of only 0.012 in. which must be measured. It has been our experience that with the equipment of the standard method, reproducible accuracy of measurement is not less than 0.010 in. Using the measuring device used in our laboratory, measurements of 0.002 in. or less have been reproduced quite easily. It is also of interest to superimpose the average 24-hr. moisture contents of the different samples on the individual expansion curves. It is found that the difference in per cent expansion between the 24-hr. moisture contents of the different samples ranges from 0.32 to 0.36%. To be more specific, it was found that the difference in per cent expansion between the two 24-hr. moisture contents was 0.35% for sample E, 0.33% for sample A, and 0.36% for sample C, while the other two were 0.32%. These results lead to two conclusions. In the first place, the accuracy obtainable using a rule graduated to 0.01 in. and a magnifying lens is not sufficient to define the very small increments in actual expansion. In the second place, the absolute expansion of the sample between the 24-hr. moisture contents is so small that it is lost in the error of measurement.

The 24-hr. conditioning period specified in the standard

Table II. Data and Calculations Obtained by Simpson Logging Co. Research Laboratory Test

Sample	*BD W*	*BD L*	W_1	*Moisture, %*	L_1	*Expansion, %*	W_2	*Moisture, %*	L_2	*Expansion, %*	W_3	*Moisture, %*	L_3	*Expansion, %*
1	48.1	0.375	49.5	2.9	0.387	0.12	50.8	5.6	0.403	0.28	52.5	9.2	0.418	0.43
2	47.7	0.376	49.1	2.9	0.387	0.11	50.3	5.5	0.403	0.27	52.1	9.2	0.419	0.42
3	47.8	0.373	49.2	2.9	0.385	0.12	50.5	5.6	0.400	0.27	52.5	9.8	0.417	0.44
4	47.8	0.374	49.1	2.7	0.385	0.11	50.5	5.6	0.402	0.28	52.2	9.2	0.416	0.42
5	47.7	0.370	49.3	3 4	0.383	0.13	50.5	5.9	0.398	0.28	52.3	9.6	0.414	0.44
Av.				3.0		0.12		5.6		0.28		9.4		0.43

	W_4	*Moisture, %*	L_4	*Expansion, %*	W_4	*Moisture, %*	L_5	*Expansion, %*	W_6	*Moisture, %*	L_6	*Expansion, %*
1	54.1	12.5	0.427	0.52	55.9	16.2	0.437	0.62	57.3	19.1	0.442	0.67
2	53.6	12.4	0.428	0.52	55.4	16.1	0.437	0.61	57.0	19.5	0.444	0.68
3	53.8	12.5	0.425	0.52	55.5	16.1	0.435	0.62	57.3	19.8	0.442	0.69
4	53.9	13.0	0.425	0.55	55.6	16.6	0.423	0.62	57.0	19.5	0.440	0.70
5	53.9	13.0	0.425	0.55	55.6	16.6	0.432	0.62	57.0	19.5	0.440	0.70
Av.		12.6		0.53		16.3		0.62		19.5		0.68

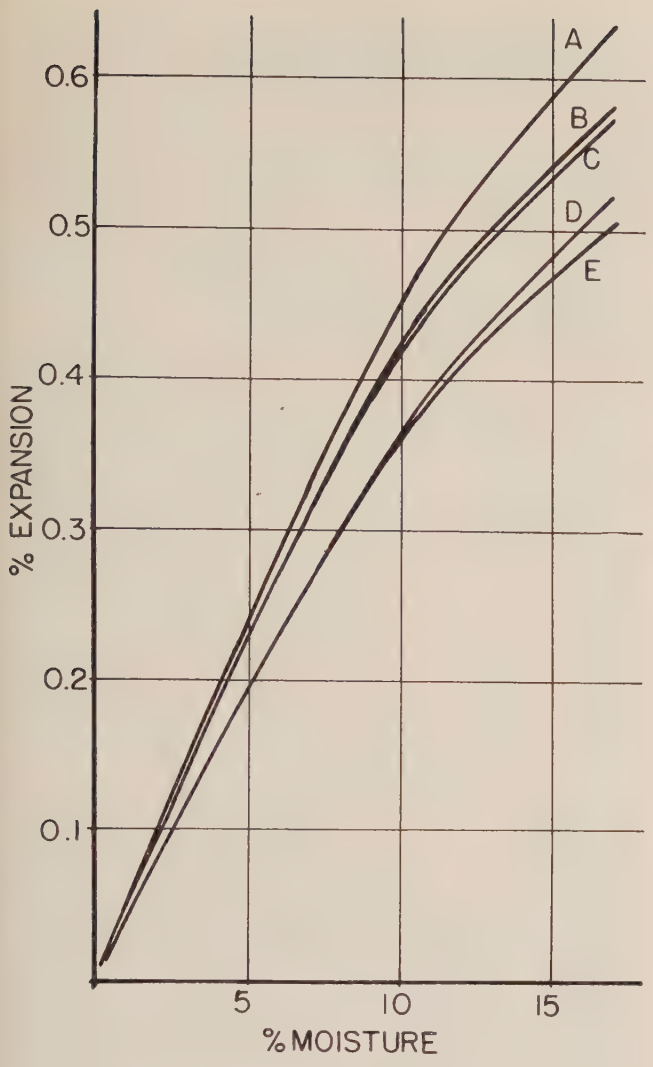

Fig. 3

method is subject to some criticism. It was found that the average moisture contents after 24 hr. conditioning at the two respective relative humidity conditions varied considerably. The average moisture contents after 24 hr. at 50% R.H. ranged from 3.4 to 7.5% and after 24 hr. at 97% R.H. the average moisture contents ranged from 14.4 to 20.3%. This is a range of 4% in one case and 6% in the other. The difference in the average moisture contents after each 24-hr. conditioning period ranged from 10.5 to 13.3%. This relatively wide range of moisture contents does not hold within the group. With the exception of sample B, the range within each group is less than 1%. The samples were measured at the end of the 24 hr. at 97% R.H. and were then replaced and left in the humidity cabinet for another 36 hr. It was found that after this time the samples had gained an additional 3 to 5% more moisture. It is presumed that the 24-hr. conditioning period at a specified constant humidity was thought to be sufficient to allow samples to attain their equilibrium moisture content at that humidity. However, this is not the case and the standard method seems to serve more as a determination of rate of expansion than of absolute expansion.

Statistical methods have been applied to results obtained by our procedure. It has been found that at the 95% confidence level, the standard deviation of the measurement of individual samples has been not greater than 0.02%. Thus, if at 15% moisture, a sample has an expansion of 0.45% it could be 0.47 or 0.43%. It was found that proper and random positioning of the samples in the humidity box was rather critical. Variation in moisture content between five samples was reduced to less than 0.5% and in expansion to less than

J. L. McCarthy presenting Shibley Award to D. E. Beasley, winner of the award

0.003 in. This was accomplished by positioning the samples in such a fashion as to break up the air flow and assure maximum circulation around every sample. In order to assure maximum accuracy it has been the practice to run five samples and to construct the expansion curve from the average moisture and expansion figures. Using this procedure it has been possible to determine and establish within very narrow limits whether a certain treatment has had a beneficial or an adverse effect on dimensional stability.

It will be noted on the graph of the expansion curves that the actual curve does not coincide with the data points. The same curve, if drawn through the points, will not pass through the origin but will intersect the moisture axis. The difference in expansion between the curve through the plotted points and the adjusted curve is 0.01% at 15% moisture. Apparently there was a constant error of measurement which caused the curve to be slightly removed from the origin. This happens occasionally but experience has shown, and interpretation of the method indicates that the curve must pass through the origin. As a result it has been considered permissible to adjust the curve so that it does this.

The fact that such an error becomes obvious and may be corrected with practically no change in expansion values is considered to be one of the advantages of this method. Another important factor to be considered is the time element, particularly if this test is to become an integrated part of quality control. It takes 48 hr. to complete the determination by the standard method, whereas it can be completed in 12 hr. by the method given in this paper.

LETTERS TO THE EDITOR

Ultimate Analysis of Black Liquor

To the Editor, *Tappi:*

We are in some difficulty regarding the ultimate analysis of black liquor from both soda and sulphate pulping processes. Up to date we have carried out our tests in accordance with the TAPPI Standard Method T 625 m-44 with reasonably satisfactory results. We now find it necessary to determine the ultimate analysis of the black liquor and are finding that we obtain very variable results and we wonder if you could advise us on the problem.

The information needed relates to the percentage composition of the total dry solids in terms of carbon, hydrogen,

oxygen, sulphur, nitrogen, and ash, and we cannot find a satisfactory method of carrying out these estimations. At the moment the most promising line appears to be the determination of carbon dioxide and sulphur dioxide after burning a sample in a bomb calorimeter, but this involves certain errors. This information is, of course, vital to us in determining the heat balances of Wagner and Tomlinson furnaces and any knowledge which you may be able to put forward would be most appreciated.

W. E. Bryden
Ernest Scott & Co. Ltd.
Levenbank, Scotland

To the Editor, *Tappi:*

I can well appreciate the predicament in which W. E. Bryden finds himself when it comes to trying to find reliable methods for the analysis of black liquor, especially ultimate analysis and heating value.

We have had to rely on commercial laboratories and our own research laboratory to develop methods of analysis and I have even had to resort to having Swedish and Finnish articles translated giving some of the work done by their Central Laboratories.

As I see it, the ultimate black liquor analysis should show the following based on the analysis of the black liquor solids as they occur in black liquor itself:

1. % Organic carbon
2. % Organic hydrogen
3. % Organic sulphur
4. % Organic sodium
5. % Sodium hydroxide } Inorganic
6. % Sodium sulphide } Inorganic
7. % Sodium sulphate } Inorganic
8. % Sodium carbonate } Inorganic
9. % Organic oxygen + nitrogen (by difference)
10. % Total—100.0

Notes: (1) Total carbon and inorganic carbon would be determined and the organic carbon calculated by difference. (2) Same way with sulphur; total sulphur and inorganic sulphur would be determined and organic sulphur calculated by difference. (3) Same way with sodium; total sodium and inorganic sodium would be determined and organic sodium calculated by difference.

The four inorganic compounds, we believe, can be determined by methods set up in the TAPPI Testing Methods T 625 m-48 and/or using similar methods of analysis recommended by any good inorganic textbook on analytical chemistry.

Our laboratory and the commercial laboratories determine carbon and hydrogen by the method recommended by ASTM D 271–42—1942, Part III, pages 32–40, maybe with some slight modifications. This is the typical combustion train method where the sample is burned in an atmosphere of pure dry oxygen, the carbon burning to CO_2 and absorbed and weighed as such, and the hydrogen burning to water vapor and absorbed and weighed as such. The trouble with this method is that it does not give the total carbon or the organic carbon because part of the organic carbon combines with the sodium in the black liquor solids and forms sodium carbonate which remains behind as ash in the combustion boat. The total carbon or organic carbon could be determined by this method if the amount of organic carbon going to sodium carbon was determined by analyzing the ash in the combustion boat for sodium carbonate and subtracting the amount of sodium carbonate originally present in the black liquor sample.

An indirect method of calculating the total carbon and organic carbon from the laboratory combustion analysis is given on pages 602 and 603 of "Pulp and Paper Manufacture," Vol. I, 1st Ed., 1950, published by McGraw-Hill Book Co., and can be used if desired instead of a direct laboratory analysis as suggested in the preceding paragraph of this letter. In either case, an elementary analysis of the ash must be made.

As an alternate to the TAPPI method for total sulphur, I believe that it may also be obtained by analyzing the bomb calorimeter washings for total sulphur.

Total sodium may be determined by the uranyl-zinc acetate method—TAPPI T 623-44 or by the spectrophotometer. The spectrophotometer method is much quicker.

As indicated organic oxygen plus nitrogen is calculated by difference. Nitrogen by itself is hardly ever determined since it amounts to only 0.1 to 0.2%.

The heating value is usually determined by burning a weighed sample in an oxygen bomb calorimeter and measuring the temperature rise of the bomb and the water in which it is immersed. The method used is similar to that used for determining the calorific value of coal and oil and is described by the ASTM—1942, Part III: (1) for coal, D 271–42, pages 37 to 41, inclusive, and (2) for oil, D 240–39, pages 223–226, inclusive. Slight modifications may have to be made when firing black liquor in the oxygen bomb calorimeter such as: (1) When firing a "wet" sample, say one containing 50% solids, the sample as such (about 2 grams) is weighed directly into the firing pan of the calorimeter but before firing, about three fourths of the water should be evaporated, say, to 85 or 90% solids. (2) When firing, in addition to using the No. 34 B&S gage iron firing wire, a small piece of cotton thread is also wound around the firing wire and allowed to touch the sample. This small piece of cotton thread first burns to incandescence and helps to start the firing of the black liquor sample. Allowance must be made for the heat value of the firing wire and the small piece of cotton thread.

From the foregoing paragraphs on calorific value determination, it will be noted that it is necessary to know the per cent solids in the liquor which is being weighed into the the firing pan of the bomb calorimeter. Therefore, it is necessary to have an accurate method of determining the per cent solids in the liquor being tested for calorific value. The TAPPI Method T 625 m-48 for total solids recommends weighing out a sample in a platinum dish and evaporating to dryness at 105°C. for 24 hr. Another quicker method which can be used is to determine the moisture by distillation with toluene, xylene, or Varsol using a reflux condenser. This method is described for chips and sawdust, pulp and tall-oil skimmings in TAPPI Methods T 3 m-44, T 208 m-45, and T 635 m-49, respectively. Varsol is the preferable solvent reagent because of its lower fire hazard and its boiling point range of 300 to 390°F. Varsol is the trade name of one of the oil fractions made by the Standard Oil Co. and is fairly easy to obtain. Our laboratory, many paper mill laboratories, and several commercial laboratories use this distillation method for determining the total solids in kraft and soda black liquor.

Another method which is just as quick and less messy, which one of the paper mill laboratories is now using, is the vacuum drying method. Here, a smaller sample is weighed into a small test tube heavy enough to stand a high vacuum. A stopper and glass tubing is fitted to the test tube so that vacuum can be applied, slowly at first (say not over 15 in. Hg) while the test tube is immersed in warm water. Later the water bath is heated to boiling and the vacuum is increased to say 25 in. Hg. By using this method a group of six samples can be dried at the same time in less than 2 hr.

After the ultimate analysis of the black liquor solids is obtained, combustion characteristic curves can be calculated and plotted for varying amounts of excess air. We usually make the following assumptions:

1. One third of the organic sulphur is burned to SO_2 or H_2S.
2. The balance of the organic sulphur goes to sodium sulphate.
3. The balance of the organic sodium goes to sodium carbonate.
4. From calculations (2) and (3), plus the inorganic compounds present in the black liquor solids, plus the amount of raw salt cake added, the total amount of ash which will be formed on burning can be calculated.
5. About 95% of the total ash leaves the furnace as smelt and 5% as dust loss up the stack and in the boiler passes.

6. From the sodium sulphate formed in calculation (2), plus the raw salt cake added and an accurate estimation of the sodium sulphate reduced to sodium sulphide, the amount of oxygen supplied by the sodium sulphate can be calculated.

Detailed calculations to obtain the same results by a slightly different method are shown on pages 599 to 620, inclusive, in "Pulp and Paper Manufacture," Vol. I, 1st Ed., 1950, published by McGraw-Hill Book Co.

E. H. KENNEDY
Paper Mill Equipment Engineering Dept.
Combustion Engineering-Superheater, Inc.

To the Editor, *Tappi:*

I turned over your letter of January 5, enclosing a letter from W. E. Bryden of Ernest Scott & Co. Ltd., Engineers of Scotland, to our W. J. Ervin. Jack has replied in a memo to me of Jan. 13, 1953, and has comprehensively covered our points of view on Mr. Bryden's comments. Most of the determinations in question have been done in our laboratories at one time or another and I believe the procedures as suggested by Mr. Ervin are practical.

We are very interested in Mr. Bryden's reactions to the attached suggestions and would welcome correspondence from him. The problem which he has outlined is common to all of us in the kraft pulping industry and an interchange of ideas would be very beneficial. We would be glad to exchange data and to examine the procedures further.

M. B. PINEO, *Technical Director*
Brunswick Pulp & Paper Co., Brunswick, Ga.

MR. ERWIN'S MEMO TO MR. PINEO Re. Suggested Procedure for Ultimate Analysis of Black Liquor

I agree with Mr. Bryden that the bomb calorimeter method seems to offer the most promise but contains certain errors.

This method could give good results on sulphur and carbon. In the high-pressure oxygen atmosphere of the bomb the sulphur should all be oxidized to sulphates in the ash or SO_3 which would be dissolved in a small amount of water placed in the bomb prior to firing. After firing the pressure would be released slowly through an absorption train of concentrated H_2SO_4, $CaCl_2$ drying tube, and a tared Geissler potash bulb filled with concentrated KOH and having a $CaCl_2$ tube on the exit end. The increase in weight of the potash bulb would be equal to the free carbon dioxide.

There is one and possibly two errors that will affect the free CO_2 determination. The first is the CO_2 remaining in the bomb at atmospheric pressure. This can be corrected knowing the pressure before absorption and the weight of CO_2 absorbed.

$$\frac{\text{Initial atmospheric pressure} + \text{weighed } CO_2}{\text{Initial atmospheric pressure} - 1} = \text{Total } CO_2$$

The other possible error would be SO_2 that was unoxidized to SO_3 in the bomb. The amount of SO_2 can be checked, however, by passing it through an iodine solution in the absorption train.

After the absorption of the free CO_2 the bomb is opened and the fuel cup containing the ash placed in a flask containing a little CO_2 free distilled water. The stopper to the flask contains an inlet tube for nitrogen, an exit tube connected to the absorption train and a thistle tube with stopcock for adding HCl. HCl is added slowly to the flask and the evolved CO_2 is purged through the absorption train with nitrogen gas. The increase in weight represents the combined CO_2 of the ash.

At the time the fuel cup is removed, the bomb cover, valve, and bomb walls are washed down with distilled water. The washings are transferred to a beaker and titrated with 1/10 N Na_2CO_3 to determine the total acid in the water. Following the titration, the water is acidified with HCl and the sulphates determined by $BaCl_2$ precipitation. The ash solution, after the CO_2 has been evolved, is also checked for sulphates.

The total acid titration minus the equivalent 1/10 N Na_2CO_3 of the sulphuric acid will give the amount of nitric acid. The nitrogen in the sample can be calculated from this figure. To reduce the error due to atmospheric nitrogen the bomb should be filled with oxygen to 35 atmospheres and released to atmospheric pressure a couple of times prior to pressurizing for firing.

The sulphates in the ash and the water in the bomb will represent the total sulphur in the black liquor sample.

The CO_2 absorbed from the gas in the bomb plus that in the ash will represent the total carbon present in the sample.

I do not believe it would be practical to try to determine the hydrogen with a bomb calorimeter as the sulphuric acid formed would absorb an undeterminable amount of the water produced. A modification of the ASTM method for ultimate analysis of coal might be used for determining the amount of hydrogen in kraft black liquor.

W. J. ERVIN

To the Editor, *Tappi:*

I assume that Mr. Bryden is having no difficulty with the regular routine of black liquor analysis, but his difficulty arises with the ultimate analysis of the solids. The analysis of the solids is carried out by means of a laboratory combustion with oxygen at 1250°F. This will also include an analysis of the inorganic residue. The sulphur can be obtained separately by analysis of the washings from the bomb calorimeter test. This latter test is of course carried out in any case to determine the B.t.u. of the black liquor solids. The details of the combustion with oxygen are available in any book on organic analysis. It just happens that I have in front of me now a suitable apparatus as shown in "Organic Chemistry" by Fieser and Fieser, published by Heath & Co. of Boston. The apparatus is shown on page 17, but I am sure that any book on the subject will give sufficient information for carrying out the ultimate analysis.

Your correspondent may be having a difficulty which I have noticed from time to time and it is in the evaporation of the black liquor to obtain the solids. This should be carried out very carefully.

J. McK. LIMERICK, *Research Director*
Bathurst Power and Paper Co. Ltd.
Bathurst, N. B.

To the Editor, *Tappi:*

Replying to the letter of W. E. Bryden of Ernest Scott & Co., Ltd. of Scotland, we have had no direct experience on the ultimate analysis of black liquor. As suggested, a peroxide bomb fusion of encapsulated black liquor should, when corrected for blank determination, give good results for carbon and sulphur via their oxides. Also, nitrogen is easy by the Kjeldahl method. Ash is easy, but the interpretation is difficult because one does not know the form the material was in in the black liquor. We prefer sulphated ash for exacting work because sodium sulphate is less volatile than the carbonate and, also, a variable quantity of the black liquor's sulphur is retained in the unsulphated ash.

The big difficulty is hydrogen and oxygen. I would suggest being arbitrary as to what is present as moisture and what is organically combined. Dry at a moderate temperature, perhaps 70°C., under good vacuum over phosphorus pentoxide to prevent air oxidation and pickup of carbon dioxide, etc. The liquor (diluted if necessary), can be placed on ignited asbestos to increase surface area for rapid drying. I presume he is dealing with evaporated black liquor which already has had the volatile organic compounds removed.

A. P. YUNDT
Camp Manufacturing Co.
Franklin, Va.

To the Editor, *Tappi:*

With reference to the letter of W. E. Bryden, we would undertake to determine carbon and hydrogen on the solids

by conventional combustion techniques. Using microcombustion methods, with a universal combustion tube filling, and adding potassium dichromate to the sample in the boat before combustion to eliminate retention of carbon dioxide by the cationic ash, we believe good results should be obtained.

Sulphur should be found satisfactorily by peroxide or oxygen bomb combustion to sulphate. Nitrogen should be small, and determinable by the Kjeldahl method. If there is any question of nitrates, they could be reduced beforehand. Ash should be determined as sulphated ash to avoid loss of alkali, i.e., charring the solids, adding a little dilute sulphuric, acid, evaporating to dryness, and igniting at low temperature. Oxygen would normally be determined by difference.

B. L. Browning, *Research Associate*
Institute of Paper Chemistry, Appleton, Wis.

Influence of Resin Bonds

To the Editor, *Tappi:*

In *Tappi* 32, No. 8 (August, 1949) an article appeared. "Influence of Resin Bonds on the Water Immersion Stability of Paper Base Laminates," by M. P. Seidel.

In this article are indicated (Table I) the methods of control for the phenolic laminating varnishes. Since we have found some difficulties in making the Poly Time Test I should be very much obliged to you if you would send me the details on the apparatus and methods to carry out this test.

R. S. Cirla
Milan, Italy

To the Editor, *Tappi:*

The Poly Time Test which was referred to in my paper is quite simple and capable of a fair degree of precision with reasonable care. The test is carried out by weighing a 20 ± 0.5-gram sample of the varnish into a thin-walled glass container. We used radio tube blanks, but I believe that the shape of the container is relatively unimportant as long as similar containers are used for each determination. This container along with an accompanying glass staining rod is placed into a high-temperature thermostat (we used Fisher Scientific Co. bath wax, a hydrogenated cottonseed oil—at 150 ± 0.5°C.). The varnish is stirred continuously during the duration of the test. The "end point" of the determination is the point at which a "string" of the varnish fractures with a rubbery snap. This is similar to the rupture of an ordinary rubber band.

Our studies indicate that this test is a function of: (1) the solids content of the varnish, (2) the type of solvent used, (3) the temperature of the bath, and (4) the type of varnish being investigated. The time required to raise the temperature of the varnish from room temperature to 150°C. is about 5 min.

Very approximately we have rated varnishes as: (1) fast, gels in 3 to 6 min.; (2) usual, gels in 8 to 12 min.; (3) slow, gels in 15 to 20 min.; (4) impractical for laminating paper, greater than 25 min. All of these figures apply to varnishes at 50% solids using alcohol, alcohol-water, or alcohol-toluene as the solvent.

M. P. Seidel
Westinghouse Electric Corp.
Sharon, Pa.

Bausch & Lomb Glossmeter

To the Editor, *Tappi:*

Thank you for subject letter inquiring about our policy concerning any future manufacture of our glossmeter.

We know that there are a number of companies very much interested in getting our instrument back on the market, notable among these being St. Regis Paper Co. and the Provincial Paper Co. in Canada. However, before we would undertake the manufacture again, we would like to have more details and pertinent information. If you could answer the following questions, it would be of great help to us in making a decision.

1. Are there any other instruments commercially available that can do the job?
2. How many instruments would be needed?
3. Would it be in order for you to contact your members to determine possible total sales?

We have maintained a policy of keeping spare parts for the instruments we have made. These parts are limited to the usual parts that are subject to wearing out. If we made another lot of glossmeters, we would like to make them all in one lot and would, of course, continue to maintain both these and the older instruments from a service standpoint in the future. Because of the limited sales of this type of product, we do not feel that we could put on any promotional campaign, but rather would be pretty much of a firm commitment from the various companies interested before proceeding with such a manufacturing order.

It is hoped that the above will be helpful to you, and we look forward with interest to your reply.

J. Westcott Wright, *Asst. Manager*
Analytical Instrument Dept.
Bausch & Lomb Optical Co.
Rochester 2, N. Y.

Ed. Note: The Editor of *Tappi* suggests that individuals and companies interested in obtaining the Bausch and Lomb glossmeter advise the Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y. This information will be forwarded to Bausch & Lomb for its information.

Glue Lap Joints

To the Editor, *Tappi:*

We have been considering the replacement of a stitched manufacturers joint on some corrugated cases by glue lapping. It would be of some assistance to know to what extent the glue lap joint has been introduced in the United States. Please let me have the following information:

1. Has the glue lap joint replaced the stitched joint to a large extent?
2. If so, does it apply to A and B flute containers or only to B flute?
3. Is the glue lap joint satisfactory if straw is used as a corrugating medium or is it satisfactory only with kraft or semichemical fluting?

P. Podolier, *Engineer*
Bowaters Fibre Containers Ltd.
Croydon, England

To the Editor, *Tappi:*

Your letter to the Editor of *Tappi* has been referred to me. My company is not using the glue lap joint. The following information is based on conversation with other individuals:

1. The glue lap joint has not replaced the stitch joint to a large extent.
2. The glue lap joints which I have observed have, in all cases, been on B flute containers. However, I am certain that the process is not restricted to B flute alone.
3. The glue lap boxes, which I have observed, have all contained kraft or semichemical corrugating medium. However, I can see no objection to the use of straw. Rough handling tests made on the glue lap box have apparently, without exception, shown that the glued lap is not the weak point in the box. Failures invariably occur elsewhere in the box than in the manufacturing joint. This is, of course, based on the premise that the adhesive bond between the corrugating medium and the liners is a satisfactory one.

Burt Mendlin, *Chairman*
TAPPI Corrugated Containers Committee

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Calendar of TAPPI Meetings

NATIONAL MEETINGS

Plastics Conference, New York State College of Forestry, Syracuse, N. Y., September 15–16, 1953.

Testing Conference, Battelle Memorial Institute, Columbus, Ohio, September 21–23, 1953. (Wax Testing Committee and Paper Testing Committee.)

Tenth Fibrous Agricultural Residues Conference, Belleville, Ontario, October 8–9, 1953.

Third Corrugated Containers Conference, Statler Hotel, New York, N. Y., October 15–16, 1953.

Eighth Engineering Conference, Sheraton-Mt. Royal Hotel, Montreal, P. Q., October 26–29, 1953.

Seventh Alkaline Pulping Conference, Rice Hotel, Houston, Texas, November 18–20, 1953.

Thirty-ninth Annual Meeting, Commodore Hotel, New York, N. Y., February 15–18, 1954.

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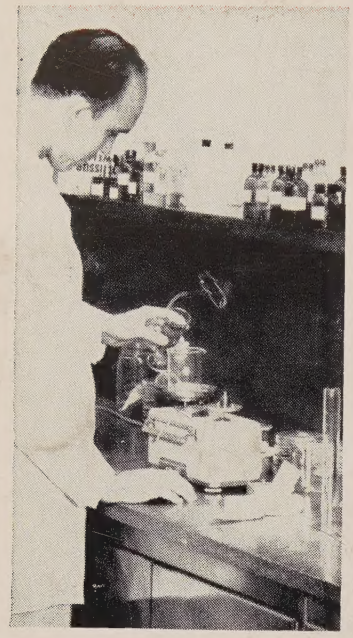

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